THE

GEOLOGICAL MAGAZINE:

OR,

Monthly Journal of Geology:

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

NOS. CCCLXXIX TO CCC.XC.

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., F.Z.S., F.R.M.S.,

OF THE BRITISH MUSEUM OF NATURAL HISTORY;

PRESIDENT OF THE PALÆONTOGRAPHICAL SOCIETY,

AND VICE-PRESIDENT OF THE MALACOLOGICAL SOCIETY;

MEMBER OF THE LYCEUM OF NATURAL HISTORY, NEW YORK; AND OF THE AMERICAN PHILOSOPHICAL SOCIETY, PHILADELPHIA; HONORARY MEMBER OF THE YORKSHIRE PHILOSOPHICAL SOCIETY; OF THE GEOLOGISTS' ASSOCIATION, LONDON; OF THE INSTITUTION OF MINING AND METALLURGY, LONDON; OF THE GEOLOGICAL SOCIETIES OF EDINBURGH, GLASGOW, HALIFAX, LIVERPOOL, AND SOUTH AFRICA; CORRESPONDING MEMBER OF THE GEOLOGICAL SOCIETY OF BELGIUM; OF THE IMPERIAL SOCIETY OF NATURAL HISTORY OF MOSCOW; OF THE NATURAL HISTORY SOCIETY OF MONTREAL; AND OF THE MALACOLOGICAL SOCIETY OF BELGIUM.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., F.C.S., &c.

WILFRID H. HUDLESTON, M.A., F.R.S., V.P.G.S., F.L.S., F.C.S.

GEORGE J. HINDE, PH.D., F.R.S., F.G.S., &c.

AND

HORACE BOLINGBROKE WOODWARD, F.R.S., F.G.S., &c.

NEW SERIES. DECADE IV. VOL. III.

JANUARY—DECEMBER, 1896.

LONDON:

MESSRS. DULAU & CO., 37, SOHO SQUARE.

F. SAVY, 77, BOULEVART ST.-GERMAIN, PARIS.

1896.

HERTFORD :
PRINTED BY STEPHEN AUSTIN AND SONS.

Geology
MC
G29
M27
33

LIST OF PLATES.

PLATE		FACING PAGE
I.	Restoration of *Compsognathus longipes*, Wagner	1
II.	,, ,, *Scelidosaurus Harrisonii*, Owen	5
III.	,, ,, *Hypsilophodon Foxii*, Huxley	6
IV.	,, ,, *Iguanodon Bernissartensis*, Boulenger	7
V.	"Neptunic Dike" of Oligocene Sandstone cutting Neocomian Clays	49
VI.	The Merjelen Lake and the Aletsch Glacier	97
VII.	Scene of the Ice-Avalanche, Altels Glacier	103
VIII.	Charles Wachsmuth	189
IX.	*Triarthrus Beckii*, Green (Beecher)	193
X.	Skeleton of *Aptornis defossor* (Owen)	241
XI.	Two types of African Lake-Shores	324
XII.	Skeleton of *Diaphorapteryx Hawkinsi*, Forbes	337
XIII.	Some Original Members of the Palæontographical Society	385
XIV.	*Coccoteuthis hastiformis*, Rüppell, sp.	439
XV.	Slices of Nummulitic Limestone (Eocene)	487
XVI.	Upper Chalk Belemnites	529

LIST OF ILLUSTRATIONS IN THE TEXT.

PAGE

Sketch of *Compsognathus longipes*, Wagner 4

Restoration of *Hypsilophodon Foxii*, Huxley. (After Hulke.) 6

Table of British Strata, with North American Equivalents 9

Etoblattina Deanensis, sp. nov. 12

Section of Perlitic Rock from Jalisco, in Mexico 18

Iocrinus and *Merocrinus* 73

Merocrinus Salopiæ, sp. nov. 74

Diagram-map of the Comrie Earthquake 77

Diagram of Seismic Focus 78

Diagram of the Merjelen Lake 97

Diagram of old overflow level of the Merjelen Lake 99

Diagram of Ice-Avalanche on the Gemmi Pass 103

Cross-section of the Valley below the summit of Altels 104

Section from Ben Muich Dhui to Strathmore 110

Section from Lesmahagow to Caithness 111

Pelvis of *Cryptoclidus Oxoniensis* (Phillips) 146

Plan of the Baden District 149

Longitudinal Section of the Baden District 150

Transverse ,, ,, ,, ... 150

Mineral Springs of Baden, Switzerland 151

Diagram showing Relationship of Subgenera of *Cheirurus* 166

General Range of Subgenera of *Cheirurus* in Europe 167

Pleistocene Beds of Malta 203

Section across Ben Lawers to Crieff 211

Section across Craig Na Challeich to Loch Earn 213

Section across the Pass of Leny 215

Two Sections through Eocene Beds at Bincombe 246

Section across Northern Somali-land 292

Archæodiadema Thompsoni, gen. et sp. nov. 318

PAGE

Section along the base of the North Cliff, Southwold 355

Anchisaurus colurus, Marsh 391

Compsognathus longipes, Wagner 392

Ceratosaurus nasicornis, Marsh 392

Brontosaurus excelsus, Marsh 394

Stegosaurus ungulatus, Marsh 395

Scelidosaurus Harrisoni, Owen 396

Triceratops prorsus, Marsh 396

Camptosaurus dispar, Marsh 397

Laosaurus consors, Marsh 398

Hypsilophodon Foxii, Huxley 398

Iguanodon Bernissartensis, Boulenger 399

Claosaurus annectens, Marsh 399

Subclymenia evoluta, Phillips, sp. 417

Listracanthus spinatus, sp. n. 425

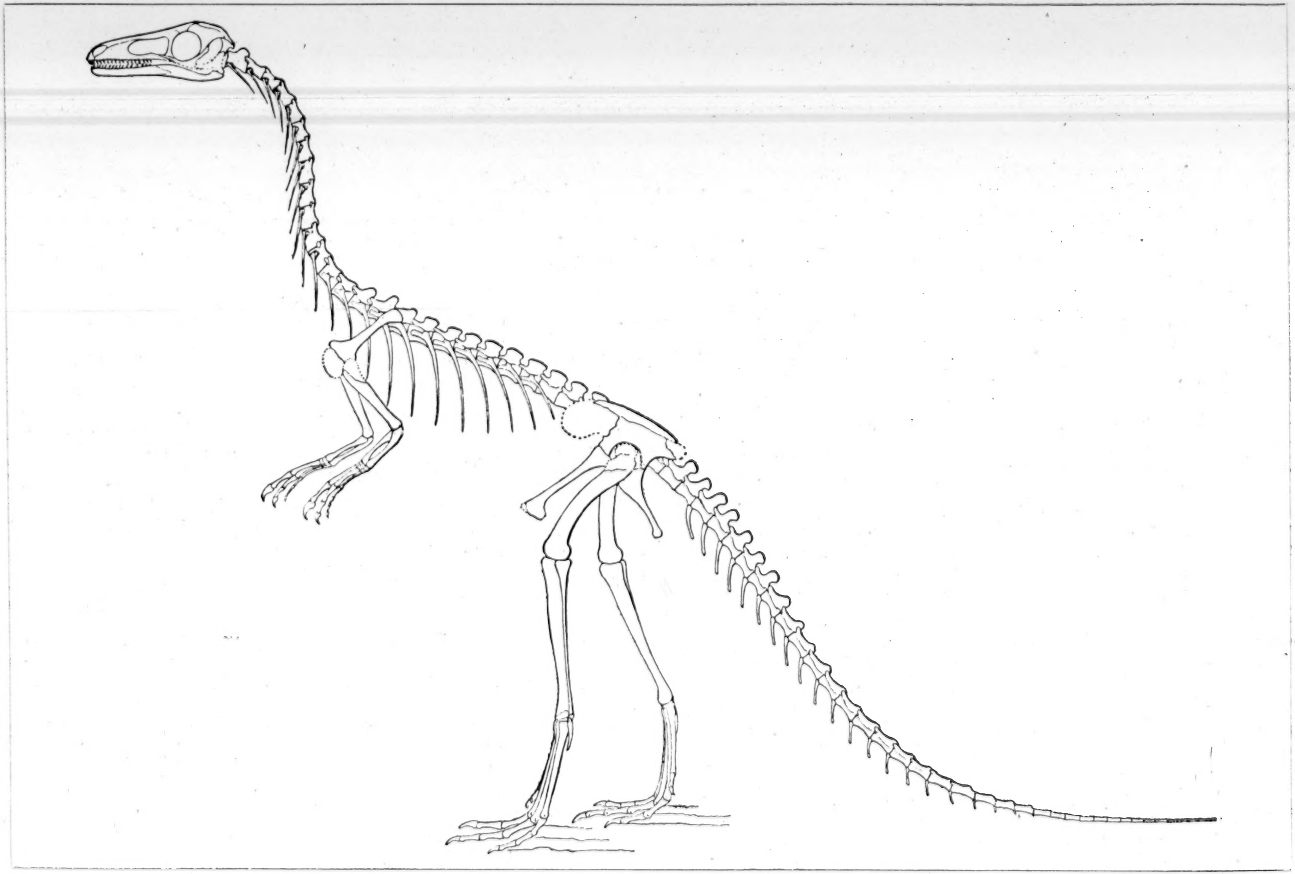
Profile of anterior part of Skull of *Nesopithecus Roberti*, gen. et sp. nov. . . 433

Palatal view of same Skull of *Nesopithecus Roberti* 434

Left Mandibular Ramus of *Nesopithecus Roberti* 435

Lenticle of Quartzite at Llansadwrn 552

Map of the Exmoor Earthquake, January 23, 1894 555



Restoration of *Compsognathus longipes*, Wagner. One-fourth natural size. Jurassic, Bavaria.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. III.

No. I.—JANUARY, 1896.

ORIGINAL ARTICLES.

I.—Restoration of some European Dinosaurs, with Suggestions as to their Place among the Reptilia.[1]

By Professor O. C. Marsh, M.A., Ph.D., LL.D., F.G.S.;
of Yale College, New Haven, U.S.

(PLATES I–IV.)

For several years I have been engaged in investigating the Dinosaurs of North America, where these extinct reptiles were very abundant during the whole of Mesozoic time. The results of my study have been published from time to time, and I have already had the honour of presenting some of these to the British Association. In carrying out this investigation so as to include the whole group of Dinosaurs, wherever found, and bringing all under one system of classification, it has been necessary for me to study the remains discovered in Europe, and I have made several visits to this country for that purpose.

In comparing the forms known from the two continents, certain important differences, as well as some marked resemblances between the two, have been observed, and placed on record. In concluding my investigations of the North American forms, I have fortunately been able to make restorations of the skeletons of quite a number of very complete type specimens, and this has proved a most instructive means of comparing those from different horizons, and of different groups, among the known Dinosauria of America.

The success of this plan rendered it very desirable to extend it, if possible, to the best-known forms of European Dinosaurs. This I have been enabled to do in a few instances, and the main object of the present paper is to lay these latest results before you.

In approaching the subject of European Dinosaurs, and especially those of England, where the study of the group first began, I am well aware that I am on delicate ground, since many and various opinions have been expressed in regard to the nature of the remains here discovered, and particularly as to the form and appearance during life of the animals they represent. I may, perhaps, be permitted, in this connection, to say, what has often occurred to me, that the Dinosaurs seem to have been rather unfortunate, and

[1] Abstract of paper read before Section C, British Association for the Advancement of Science, Ipswich, September 14th, 1895.

carnivorous Dinosaurs are bipedal, and this is true of the footprints of many herbivorous forms.

In the present restoration of *Compsognathus* (Plate I) I have tried to represent the animal as walking, in a characteristic and lifelike position.

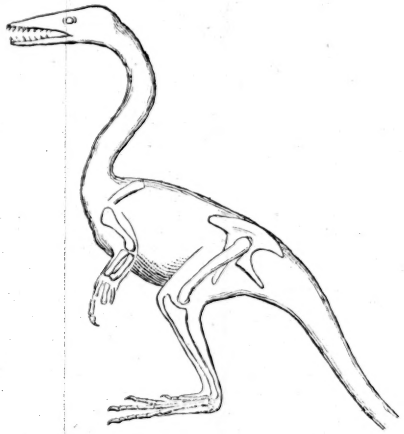


Fig 1.—Sketch of *Compsognathus longipes*, Wagner. One-seventh natural size. (After Huxley.)

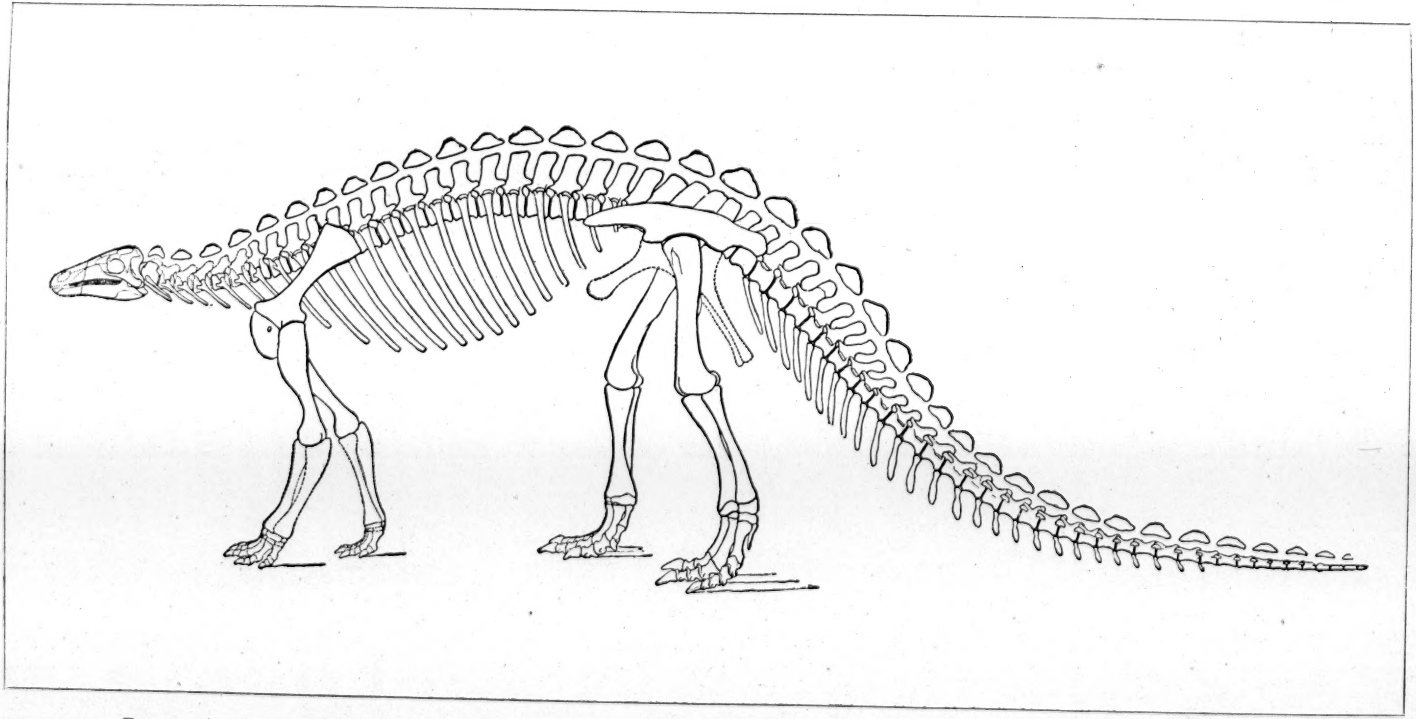
Scelidosaurus. Page 5 (Plate II).

The second of these restorations is that of *Scelidosaurus Harrisonii*, of Owen, shown one-eighteenth natural size on p. 5 (Plate II). This reptile was an herbivorous Dinosaur of moderate size, related to *Stegosaurus*, and was its predecessor from a lower geological horizon in England. This restoration is essentially based upon the original description and figures of Owen (Palæontographical Society, 1861). These have been supplemented by my own notes and sketches, made during examinations of the type specimen, now in the British Museum.

Scelidosaurus is a near relative, as it were, of one of our American forms, *Stegosaurus*, now represented by so many specimens that we know the skull, skeleton, and dermal armour with much certainty. The English form known as *Omosaurus* is still more nearly allied to *Stegosaurus*, perhaps identical.

A restoration of the skeleton of *Scelidosaurus*, by Dr. Henry Woodward, will be found in the British Museum Guide to Geology and Palæontology, 1890, p. 19. The missing parts are restored from *Iguanodon*, and the animal is represented as bipedal, as in that genus.

In the present outline restoration of *Scelidosaurus*, I have endeavoured merely to place on record my idea of the form and position of the skeleton, when the animal was alive, based on the remains I have myself examined. In case of doubt, as, for example, in regard to the front of the skull, which is wanting in the type



Restoration of *Scelidosaurus Harrisonii*, Owen. One-eighteenth natural size. Lower Lias. Charmouth, Dorset.

specimen, I have used a dotted outline, based on the nearest allied form. Of the dermal armour, only the row of plates best known is indicated. The position chosen in this Figure (Pl. II) is one that would be assumed by the animal in walking on all four feet, and this I believe to have been its natural mode of progression.

Hypsilophodon. (Plate III.)

The third of these restorations, that of *Hypsilophodon Foxii*, Huxley, 1870, given in outline, one-eighth natural size, in Plate III, has been made with much care, partly from the type specimen and in part from other material mostly now in the British Museum. The figures and description by the late Dr. Hulke [1] were of special value, although my own conclusions as to the natural position of the animal when alive do not coincide with those of my honoured friend, who did so much to make this genus of Dinosaurs, and others, known to Science. The restoration by Dr. Hulke is shown in the subjoined diagram (Fig. 2).

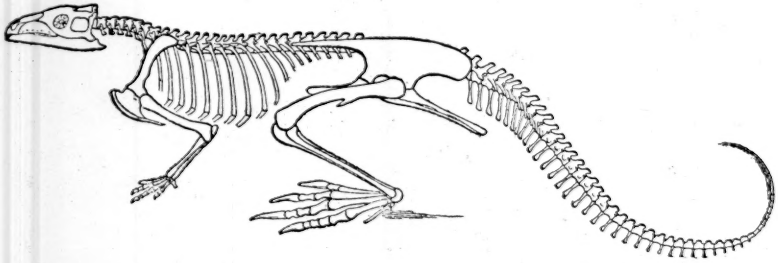


Fig. 2.—Restoration of *Hypsilophodon Foxii*, Huxley. One-tenth natural size. (After Hulke.)

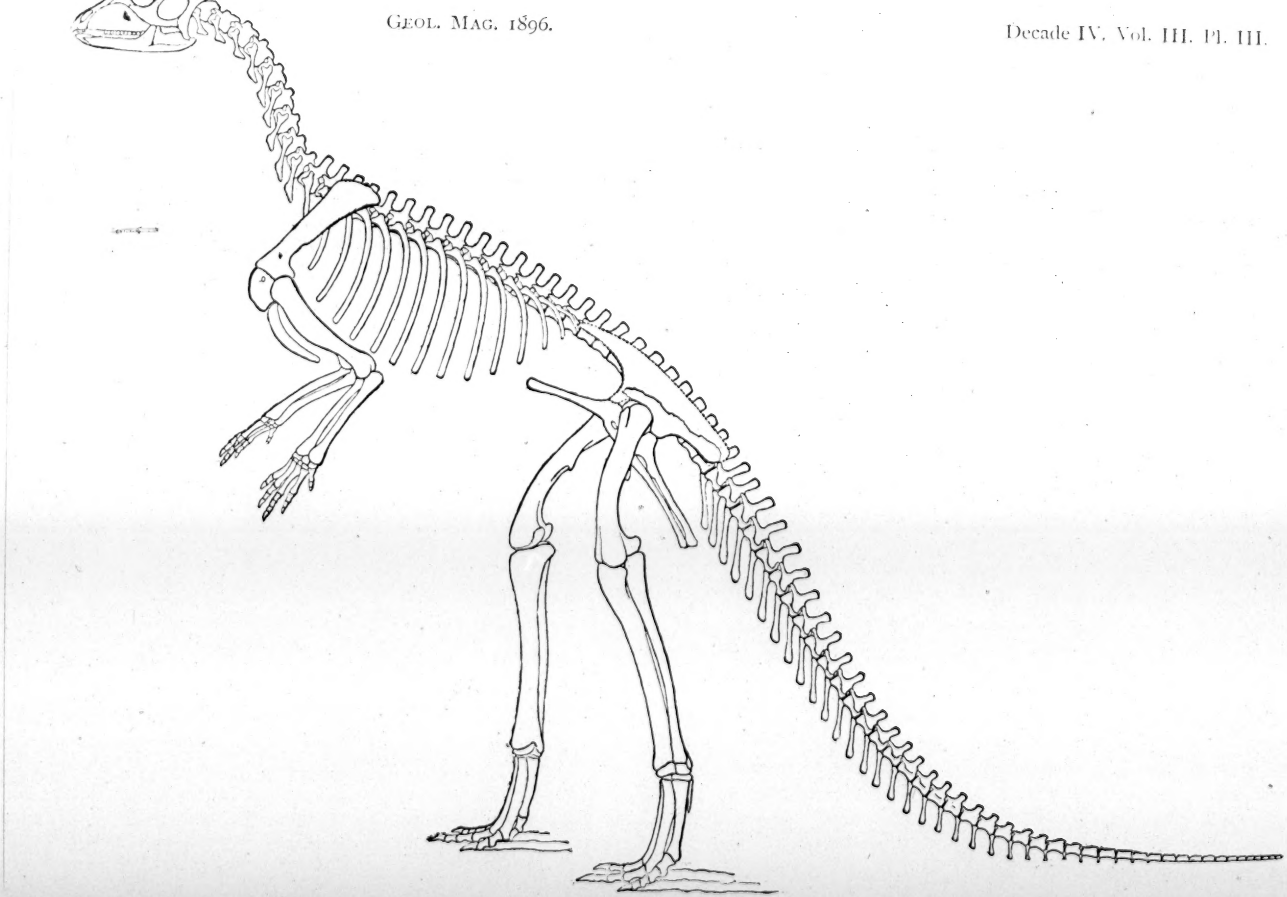
In the case of *Hypsilophodon*, a number of specimens are available instead of only one. This makes the problem of restoration in itself a simpler matter than in *Scelidosaurus*. Moreover, we have in America a closely allied form, *Laosaurus*, of which several species are known. A study of the genus *Laosaurus*, and the restoration of *Hypsilophodon* given on Plate III, will clear up several points long in doubt.

Huxley and Hulke both shed much light on this interesting genus, *Hypsilophodon*; indeed, on many of the Dinosauria. The mystery of the Dinosaurian pelvis, which baffled Cuvier, Mantell, and Owen, was mainly solved by them—the ilium and ischium by Huxley, and the pubis by Hulke. The more perfect American specimens have demonstrated the correctness of nearly all their conclusions.

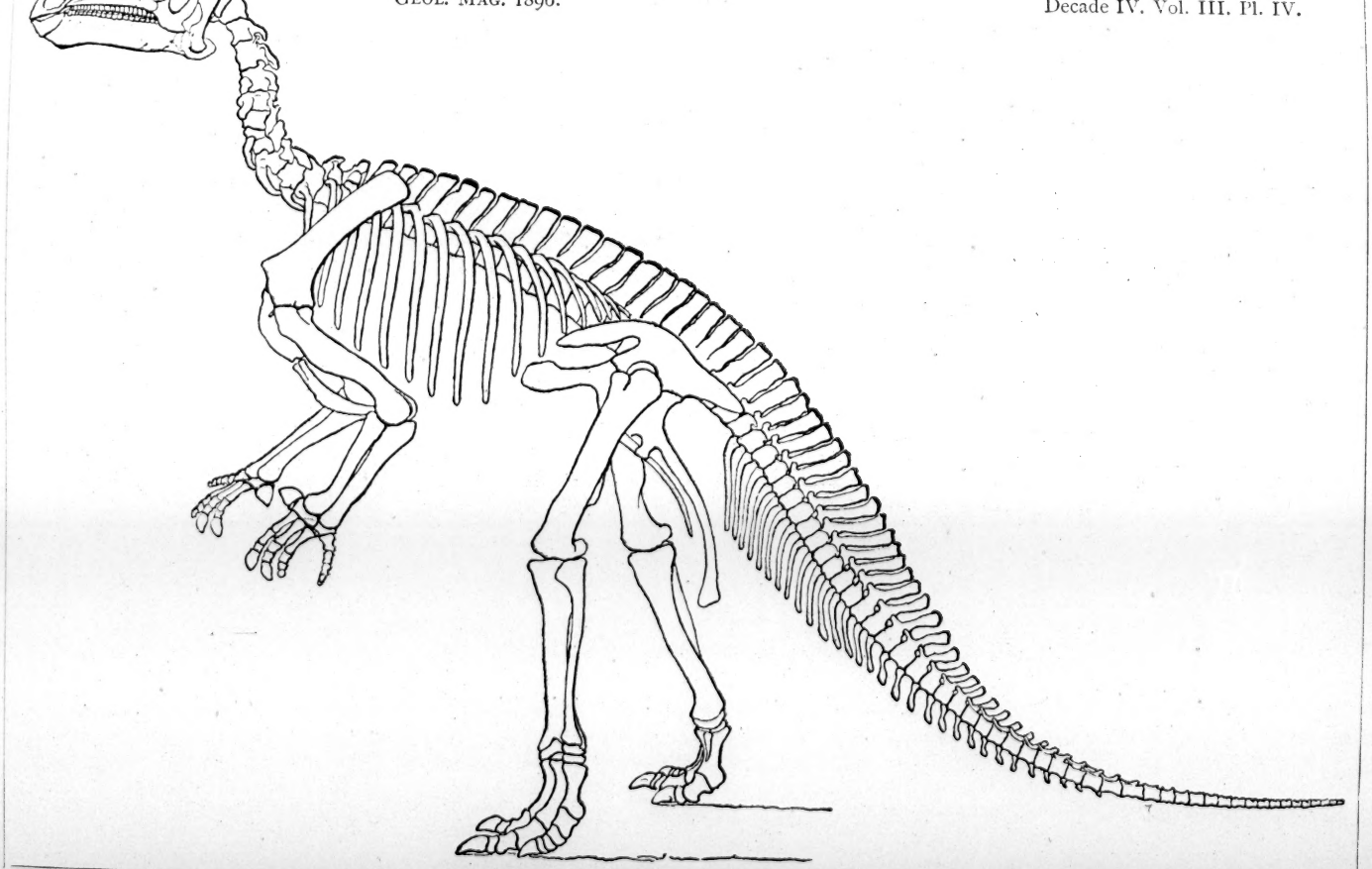
Iguanodon. (Plate IV.)

The fourth restoration here given, that of *Iguanodon Bernissartensis*, Boulenger, 1881, one-fortieth natural size, has been made in outline for comparison with American forms. It is based mainly on photographs

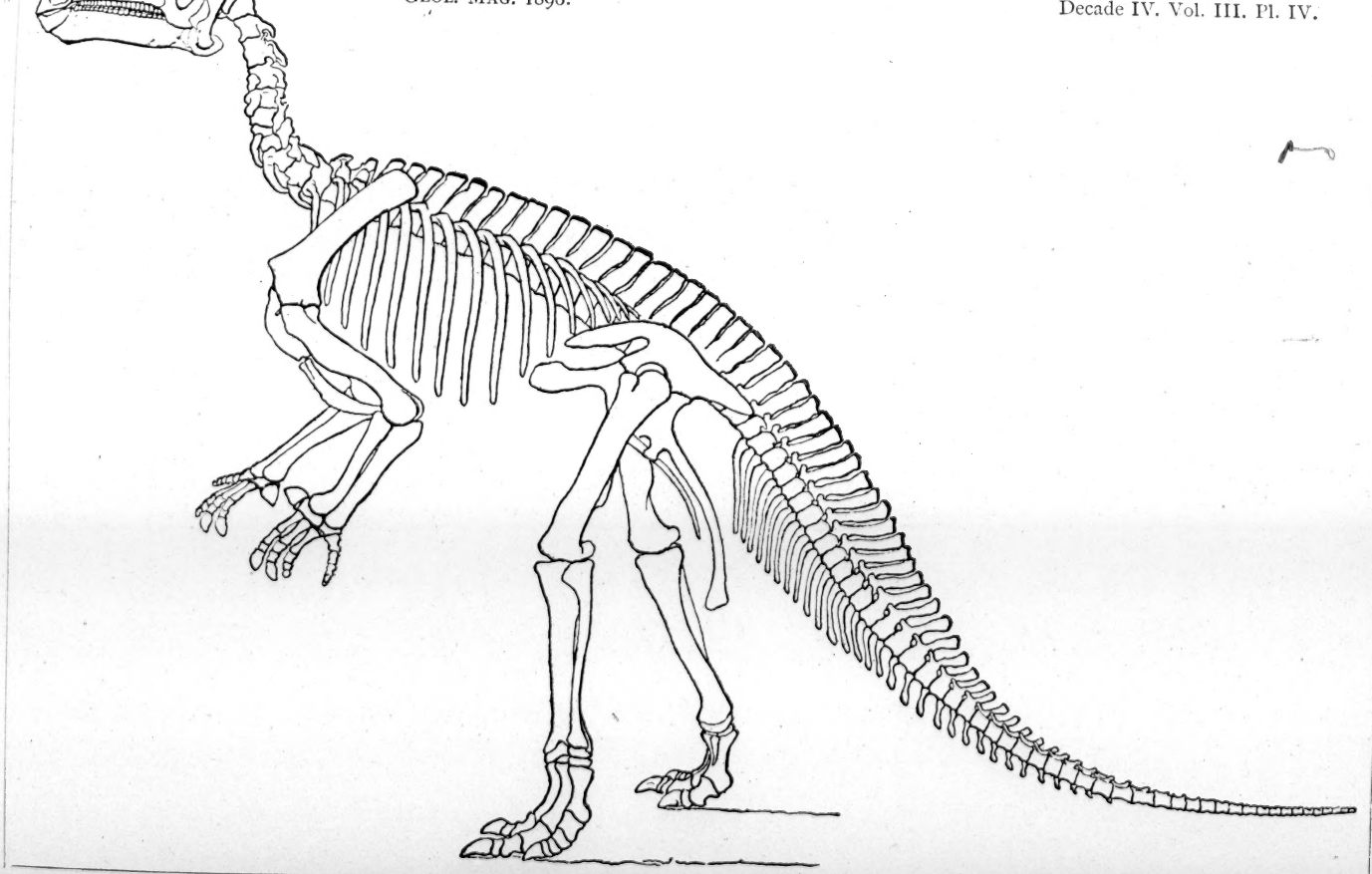
[1] Philosophical Transactions, 1882.



Restoration of *Hybsilophodon Foxii*. Huxlev. One-eighth natural size. Wealden. Cowleaze Chine. Isle of Wight.



Restoration of *Iguanodon Bernissartensis*, Boulenger. One-fortieth natural size. Wealden, Belgium.



Restoration of *Iguanodon Bernissartensis*, Boulenger. One-fortieth natural size. Wealden, Belgium.

of the well-known Belgian specimens, the originals of which I have studied with considerable care during several visits to Brussels. The descriptions and figures of Dollo[1] have been used in the preparation of this restoration. A few changes only have been introduced in the accompanying Plate, based mainly upon a study of the original specimens.

Besides the four genera here represented, no other European Dinosaurs at present known are sufficiently well preserved to admit of accurate restorations of the skeleton. This is true, moreover, of the Dinosaurian remains from other parts of the world outside of North America.

To present a comprehensive view of the Dinosaurs, so far as now known, I have prepared a plate, here shown, which gives restorations of the twelve best-known types, as I have thus far been able to reconstruct them. Of these twelve forms, eight are from America: *Anchisaurus*, a small carnivorous type from the Trias; *Brontosaurus*, *Camptosaurus*, *Laosaurus*, and *Stegosaurus*, all herbivorous, and the carnivorous *Ceratosaurus*, from the Jurassic; with *Claosaurus* and *Triceratops*, herbivores from the Cretaceous. These American forms, with the four from Europe already noticed, complete the series represented on this chart.[2] They form an instructive group of the remarkable reptiles known as Dinosauria.

The geological positions of *Compsognathus* and of *Scelidosaurus* are fully determined, but that of *Hypsilophodon* and *Iguanodon* is not so clear. The latter are found in the so-called Wealden, but just what the Wealden is I have not been able to determine from the authorities I have consulted. The Cretaceous age of these deposits appears to be taken for granted here, but the evidence as it now stands seems to me to point rather to the Upper Jurassic as their true position. If I should find the vertebrate fossils now known from your Wealden in the Rocky Mountains, where I have collected many corresponding forms, I should certainly call them Jurassic, and have good reason for so doing. Moreover, after visiting typical Wealden localities here and on the Continent, I can still see no reason for doing otherwise so far as the vertebrate fossils are concerned, and in such fresh-water deposits their evidence should be conclusive. I have already called attention to this question of the age of the Wealden, and do so again, as I believe it worthy of a careful reconsideration by English geologists.

EXPLANATION OF PLATES I–IV.

PLATE I.—Outline restoration of the skeleton of *Compsognathus longipes*, Wagner. One-fourth natural size. Jurassic, Bavaria.

PLATE II.—Outline restoration of the skeleton of *Scelidosaurus Harrisonii*, Owen. One-eighteenth natural size. Jurassic, England.

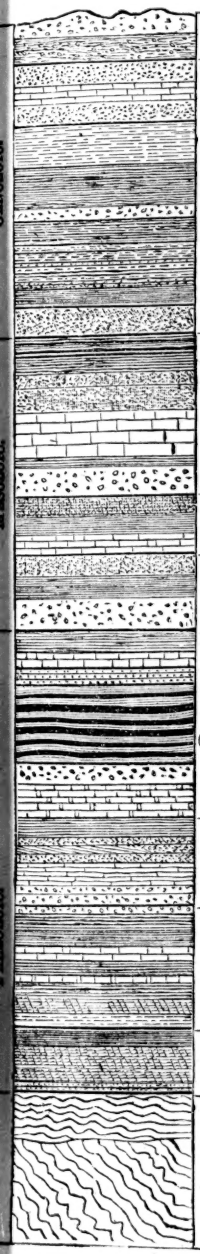
PLATE III.—Outline restoration of the skeleton of *Hypsilophodon Foxii*, Huxley. One-eighth natural size. Wealden, England.

PLATE IV.—Outline restoration of the skeleton of *Iguanodon Bernissartensis*, Boulenger. One-fortieth natural size. Wealden, Belgium.

[1] Bulletin Royal Museum of Belgium, 1882–1888.

[2] A copy of this Chart will appear in the next Number of this MAGAZINE.—EDIT. GEOL. MAG.

TABLE OF BRITISH STRATA WITH THEIR NORTH AMERICAN EQUIVALENTS, AND A LIST OF THE VERTEBRATE FOSSILS WHICH ARE FOUND IN THEM IN THE UNITED STATES.



	Recent. Quaternary.		Tapir, Peccary, Bison. *Bos, Equus, Tapirus, Dicotyles, Megatherium, Mylodon.*
Tertiary	Pliocene.	Equus Beds. Pliohippus Beds.	*Equus, Tapirus, Elephas.* *Pliohippus, Tapiravus, Mastodon, Procamelus, Aceratherium, Bos, Morotherium, Platygonus.*
Tertiary	Miocene.	Miohippus Beds. Oreodon Beds. Brontotherium Beds	*Miohippus, Diceratherium, Thinohyus, Protoceras.* *Oreodon, Eporeodon, Hyænodon, Moropus, Ictops, Hyracodon, Agriochœrus, Colodon, Leptochœrus.* *Brontotherium, Brontops, Allops, Titanops, Titanotherium, Mesohippus, Ancodus, Entelodon.*
Tertiary	Eocene.	Diplacodon Beds. Dinoceras Beds. Heliobatis Beds. Coryphodon Beds.	*Diplacodon, Epihippus, Amynodon, Eomeryx.* *Dinoceras, Tinoceras, Uintatherium, Palæosyops, Orohippus, Hyrachyus, Colonoceras, Homacodon.* *Heliobatis, Amia, Lepidosteus, Asineops, Clupea.* *Coryphodon, Eohippus, Eohyus, Hyracops, Parahyus* Lemurs, Ungulates, Tillodonts, Rodents, Serpents.
	Cretaceous.	Laramie Series, or Ceratops Beds.	*Ceratops, Triceratops, Claosaurus, Ornithominus.* Mammals, *Cimolomys, Dipriodon, Selenacodon, Nanomyops, Stagodon.* Birds, *Cimolopteryx.*
		Fox Hills Group.	
		Colorado Series, or Pteranodon Beds.	Birds with Teeth, *Hesperornis, Ichthyornis, Apatornis.* Mosasaurs, *Edestosaurus, Lestosaurus, Tylosaurus.* Pterodactyls, *Pteranodon.* Plesiosaurs, Turtles.
		Dakota Group.	
	Jurassic.	Atlantosaurus Beds Baptanodon Beds. Hallopus Beds.	Dinosaurs, *Brontosaurus, Morosaurus, Diplodocus, Stegosaurus, Camptosaurus, Ceratosaurus.* Mammals, *Dryolestes, Stylacodon, Tinodon, Ctenacodon.*
	Triassic.	Otozoum, or Conn. River, Beds.	First Mammals, *Dromatherium.* First Dinosaurs, *Anchisaurus, Ammosaurus, Bathygnathus, Clepsysaurus.* Many footprints. Crocodiles, *Belodon.* Fishes, *Catopterus, Ischypterus, Ptycholepis.*
	Permian.	Nothodon Beds.	Reptiles, *Nothodon, Eryops, Sphenacodon.*
	Carboniferous	Coal Measures, or Eosaurus Beds.	First Reptiles (?) *Eosaurus.* Amphibians, *Baphetes, Dendrerpeton, Hylonomus, Pelion.* Footprints, *Anthracopus, Allopus, Baropus, Dromopus, Hylopus, Limnopus, Nasopus.*
		Subcarboniferous, or Sauropus Beds.	First known Amphibians (Labyrinthodonts). Footprints, *Sauropus, Thenaropus.*
	Devonian.	Dinichthys Beds. Lower Devonian.	*Dinichthys, Acanthodes, Bothriolepis, Chirolepis, Cladodus, Dipterus, Titanichthys.*
	Silurian.	Upper Silurian. Lower Silurian.	First known Fishes.
	Cambrian.	Primordial.	No Vertebrates known.
		Huronian.	
	Archæan.	Laurentian.	

[To illustrate Prof. Marsh's paper on European Dinosaurs.]

II.—The European Species of *Etoblattina*, with Description of a New Form.

By Samuel H. Scudder.

FOR the convenience of students a first essay is here made to tabulate the European species of *Etoblattina*, the genus of Cockroaches most numerously represented in Carboniferous times, both in Europe and America. All the species described up to the present time are introduced, together with a new British species, a description of which is added. It will be seen that Deichmüller's var. *Stelzneri* (regarded by him as a form of *E. flabellata*) and Geinitz's var. *dyadica* (regarded by him as another form of the same) are considered distinct species; and that *E. Rollei*, Deichm., is not included, this last being more probably a *Gerablattina*. *E. Peachii*, Woodw., is also omitted, as the tegmina are undeveloped and therefore present no features which could admit it into the table. On the other hand, *Blattina intermedia*, Gold., formerly described by me as a *Gerablattina*, has had new light thrown upon it by Kliver, showing it to be an *Etoblattina*, and it is accordingly introduced here.

Table of the European Species of Etoblattina.

a^1. Tegmina broad, at most but little more than twice as long as broad; the mediastinal area usually broad at base, here generally occupying a third or more of the tegmina.

b^1. Mediastinal area tapering gradually, and relatively long, more, often much more, than four times as long as greatest breadth.

c^1. Relatively slender, the tegmina distinctly more than twice as long as broad.

d^1. Apical margin divided between the scapular and externomedian areas. 1. *E. Labachensis.*

d^2. Apical margin divided between the externomedian and internomedian areas . . . . . 2. *E. intermedia.*

c^2. Tegmina broad, not more than twice as long as broad, the immediate apex occupied by the externomedian branches.

d^1. Tegmina less than twice as long as broad; mediastinal area reaching nearly to the middle of the distal half of the tegmina; externomedian vein first forking not before the middle of the tegmina. 3. *E. propria.*

d^2. Tegmina twice as long as broad; mediastinal area hardly extending beyond the middle of the tegmina; externomedian vein first branching far before the middle of the tegmina. 4. *E. Deichmülleri.*

b^2. Mediastinal area tapering rapidly and relatively short, less, often much less, than four times as long as basal breadth.

c^1. Internomedian area long and numerously branched, falling but little short of the apex of the tegmina.

d^1. Humeral angle prominent, the tegmina less than twice as long as broad. 5. *E. Steinbachensis.*

d^2. Humeral angle roundly excised, the tegmina more than twice as long as broad . . . . . 6. *E. primæva.*

c^2. Internomedian area relatively short and with few branches, falling far short of the apex of the tegmina.

d^1. Mediastinal vein with frequent branches; scapular branches few, mostly forked deeply or compound . . . . . 7. *E. Deanensis.*

d^2. Mediastinal vein with infrequent branches; scapular branches numerous, mostly simple or only apically forked . . . 8. *E. lanceolata.*

a^2. Tegmina relatively slender, rarely less than two and a half times as long as broad; the mediastinal area usually rather slender and ribbon-shaped, not or scarcely broader at base than in the middle, and rarely occupying more than a fourth of the basal width of the tegmina.

b^1. Tegmina distinctly less than three times as long as broad.

c^1. Internomedian area long, but far from attaining the apex of the tegmina, rarely prolonged by distinct sinuosity of the main vein.[1]

d^1. Mediastinal area extending well beyond the middle of the tegmina.

e^1. Externomedian vein first branching beyond the middle of the tegmina. 9. *E. carbonaria.*

e^2. Externomedian vein first branching far before the middle of the tegmina.

f^1. Tegmina of large or medium size, well rounded at apex; externomedian area expanded, and on the margin as important as the scapular.

g^1. First scapular branch arising far before the succeeding, near the middle of the basal half of the tegmina; internomedian vein scarcely sinuate . . . . . 10. *E. russoma.*

g^2. First scapular branch arising but little before the middle of the tegmina and at ordinary distance before the succeeding; internomedian vein strongly sinuate . . . . . 11. *E. dyadica.*

f^2. Tegmina of small size, subacuminate at apex; externomedian area compressed and on margin of much less importance than the scapular . . . . . 12. *E. parvula.*

d^2. Mediastinal area scarcely, if at all, surpassing the middle of the tegmina.[2]

e^1. Scapular and externomedian veins first branching at nearly the same point.[3]

f^1. Primary offshoots of the externomedian vein numerous.

g^1. Course of the externo-internomedian interspace gently oblique, arcuate . . . . . 13. *E. Manebachensis.*

g^2. Course of the externo-internomedian interspace strongly oblique, sinuous . . . . . 14. *E. ornatissima.*

f^2. Primary offshoots of the externomedian vein only two or three in number . . . . . 15. *E. anthracophila.*

e^2. First branching of the externomedian vein far beyond that of the scapular . . . . . 16. *E. mantidioides.*

c^2. Internomedian area very long, nearly reaching the apex, or reaching the apical margin, often prolonged by distinct sinuosity of the main vein.

d^1. Mediastinal area extending well beyond the middle of the tegmina.

e^1. Scapular vein first branching far beyond the middle of the tegmina. 17. *E. Johnsoni.*

e^2. Scapular vein first branching before, often far before, the middle of the tegmina.

f^1. All the internomedian branches simple or simply forked.

g^1. Scapular vein first branching at some distance before the externomedian . . . . . 18. *E. Dohrnii.*

g^2. Scapular vein first branching but little before the externomedian.

h^1. Mediastinal and scapular branches with normal obliquity; internomedian branches frequent, with normal obliquity. 19. *E. didyma.*

h^2. Mediastinal and scapular branches very longitudinally oblique; internomedian branches exceedingly few and longitudinally oblique. 20. *E. bituminosa.*

f^2. Some apical branches of the internomedian vein compound. 21. *E. anaglyptica.*

d^2. Mediastinal area hardly reaching the middle of the tegmina.

[1] This is only conjectural in *E. mantidioides*, but indicated by the parts preserved.

[2] This is conjectural, but probable, in *E. ornatissima* by the brief extent of the scapular area.

[3] Conjectural again, but probable, with *E. ornatissima.*

e^1. Scapular vein in the middle of its course receding from the margin to reach the middle line of the tegmina . . 22. *E. leptophlebica.*

e^2. Scapular vein in the middle of its course hardly receding from the margin and nowhere nearly reaching the middle line of the tegmina . . . . . 23. *E. flabellata.*

b^2. Tegmina distinctly more than three times as long as broad; internomedian area long and slender.

c^1. Internomedian area not nearly reaching the apex of the tegmina, with no extension by the distal sinuosity of the main vein.

d^1. Tegmina less than 20 mm. long; course of the main scapular vein distinctly sinuous, and at one point nearly reaching the middle line of the tegmina . . . . . 24. *E. affinis.*

d^2. Tegmina more than 30 mm. long; course of the main scapular vein nearly or quite straight, at no point nearly attaining the middle line of the tegmina.

e^1. Tegmina subequal on distal half (apparently; the only specimen is broken), the externomedian vein with regular offshoots from the middle of the tegmina outward . . . . 25. *E. euglyptica.*

e^2. Tegmina tapering considerably throughout the distal half, the externomedian branches all arising close to the apex from two stems which unite at or before the middle of the tegmina. 26. *E. elongata.*

c^2. Internomedian area nearly reaching the apex of the tegmina by the distal sinuosity of the main vein.

d^1. Externomedian vein first forking well before the middle of the tegmina, with many branches; distal portion of anal area with numerous branches . . . . . 27. *E. Stelzneri.*

d^2. Externomedian vein first forking at some distance beyond the middle of the tegmina, with few branches; distal portion of the anal area with few branches . . . . . 28. *E. Weissigensis.*

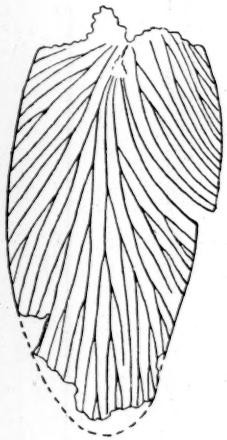


FIG. 1.

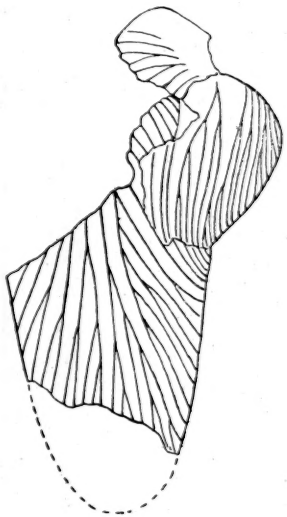


FIG. 2.

ETOBLATTINA DEANENSIS, sp. nov. (Figs. 1 and 2.)

The fore wing has a very regular elongate oval form, tapering with considerable regularity beyond the middle third of the tegmina,

the anal area by its fulness interfering a little with the regularity; it is a little more than two and a quarter times as long as broad; the costal margin has a very regular and moderately convex curve, while the inner margin, beyond the fuller and more convex anal area, is nearly straight; the tip is imperfect in the two specimens known. The veins originate slightly above the middle of the tegmina and at first all curve upward, but not so strongly as in *E. primæva*, to which this species is most nearly allied, so that the externomedian vein passes more nearly through the middle of the tegmina. The mediastinal vein passes in a scarcely sinuous course to somewhat beyond the middle of the front margin, emitting about half a dozen nearly straight simple or deeply forked branches. The scapular vein is broadly and gently sinuous, extending to the apical margin a very little above the apex, begins to fork before the middle of the proximal half of the tegmina, and has four subequidistant branches, of which the first is compound, the others forked or simple. The externomedian vein first forks near the middle of the tegmina, where it divides into two very similar, weakly arborescent, longitudinal stems carrying about ten or a dozen veinlets to the apical, and to the outer portion of the inner, margin. The internomedian vein is very regularly and rather gently arcuate, except for a slight apical sinuosity which carries it nearly to the apical sixth of the tegmina, and has about five nearly straight branches, some of the basal ones simply or doubly forked. The anal furrow is not very deeply impressed, very regularly but not very strongly arcuate, and ends at about the middle of the tegmina. The anal veins consist of two sets, rather widely separated at the base, the inner set consisting of a several-branched main stem subparallel to the anal furrow, the outer of four or five simply or doubly forked, approximated, slightly divergent nervules, more nearly longitudinal than the other set.

The two specimens known, one with its reverse, are coal black: one (Fig. 1) with its reverse is nearly perfect, having lost only the shoulder and the apical margin; the other (Fig. 2) consists of two tegmina, of one of which only the base and the anal area is preserved, and which lies partially concealing the reversed face of the other, of which the basal portion and considerable of the apex is lost. Excepting in the anal and internomedian areas the veins are pronounced, being deeply incised; in the internomedian area they are very delicate. Towards the apex of the tegmina an exceedingly delicate reticulation can be detected in the interspaces, which gives way in the centre of the tegmina to a very close series of dulled cross lines, and become in the scapular area parallel to the nearer margin.

Length of the tegmina, 38 mm.; breadth, 13·25 mm.

The two specimens differ from each other in hardly anything but the simplicity or complexity of the several branches of the main veins, particularly in the upper stem of the externomedian vein and the principal branches of the internomedian vein. In one, however, the costal margin appears to be distinctly more arcuate than in the other.

The species is plainly most nearly allied to *E. primæva*, from which it differs in its more elongate form, apical tapering, the lack of an extreme basal branch of the scapular vein, the far greater importance though later branching of the externomedian vein, the narrower and shorter internomedian area and its simpler apical branching, the more regular curve of the anal furrow, the entire system of anal veins, and the lower course of all the main veins through the middle area of the tegmina.

The specimen with reverse comes from Foxe's bridge, in the Forest of Dean, Gloucester, England. The other was collected by F. Stock at Crump meadow, in the Forest of Dean. Both are in the collection of Mr. R. D. Lacoe, in which they bear the No. 2132*a–b*, *c*.

A List of the Described European Palæozoic Cockroaches.

The species in this list are arranged alphabetically under each genus, but the genera are in a natural order. Several species, because too imperfectly known, are not mentionde, as they cannot be placed. Such are *Blattina ligniperda*, Kušta, from Lubná, Bohemia; *B. neuropteroides*, Göpp., and *B. rarinervis*, Göpp., from an unnamed locality; *B. Tischbeini*, Gold., from Hirschbach, Germany, and *B. venosa*, Gold., from Wemmetsweiler, Rhenish Prussia. *Etoblattina Peachii*, Woodw., from Kilmaurs, Scotland, is also omitted, as the undeveloped tegmina hardly allow it to be definitely placed.

Etoblattina affinis (Gold.), Löbejün and Wettin, Saxony.
,, *anaglyptica* (Germ.), Wettin, Saxony.
,, *bituminosa* (Kušta),[1] Lubná, Bohemia.
,, *carbonaria* (Germ.), Wettin, Saxony.
,, *Deanensis*, Scudd., Forest of Dean, Gloucester, England.
,, *Deichmülleri* (Gein.),[2] Weissig, Saxony.
,, *didyma* (Germ.), Wettin, Saxony; Manebach, Saxe Weimar.
,, *Dohrnii*, Scudd., Wettin, Saxony.
,, *dyadica* (Gein.),[3] Weissig, Saxony.
,, *elongata* (Gein.), Weissig, Saxony.
,, *euglyptica* (Germ.), Wettin, Saxony.
,, *flabellata* (Germ.), Wettin and Weissig, Saxony.
,, *intermedia* (Gold.), Wemmetsweiler, Rhenish Prussia.
,, *Johnsoni*, Woodw., Dudley, England.
,, *Labachensis* (Gold.), Labach, Rhenish Prussia.
,, *lanceolata* (Sterz.), Lugau, Saxony.
,, *leptophlebica* (Gold.), Löbejün, Saxony.
,, *Manebachensis* (Gold.), Manebach, Saxe Weimar.
,, *mantidioides* (Gold.), Durham, England.
,, *ornatissima*, Deichm., Grügelborn, Rhenish Prussia.
,, *parvula* (Gold.), Löbejün, Saxony.
,, *primæva* (Gold.), Saarbrücken, Rhenish Prussia.
,, *propria*, Kliver, Saarbrücken, Rhenish Prussia.
,, *russoma* (Gold.), Löbejün, Saxony.
,, *Steinbachensis*, Kliv., Steinbachthal, Rhenish Prussia.
,, *Stelzneri* (Deichm.),[4] Weissig, Saxony.
,, *Weissigensis* (Gein.), Weissig, Saxony.

[1] *Blattina* (*Etoblattina*) *bituminosa*, Kušta.
[2] *Blattina* (*Etoblattina*) *carbonaria*, var. *Deichmülleri*, Gein.
[3] *Blattina* (*Etoblattina*) *flabellata*, var. *dyadica*, Gein.
[4] *Etoblattina flabellata*, var. *Stelzneri*, Deichm.

Gerablattina clathrata (Heer), Manebach, Saxe Weimar.
,, *Geinitzi* (Gold.), Löbejün, Saxony.
,, *Germari* (Gieb.), Wettin, Saxony.
,, *Goldenbergi* (Mahr), Manebach, Saxe Weimar.
,, *Mahri* (Gold.), Manebach, Saxe Weimar.
,, *Münsteri*, Scudd., Wettin, Saxony.
,, *producta*, Scudd., Wettin, Saxony.
,, *robusta*, Kliv., Wemmetsweiler, Rhenish Prussia.
,, *Rollei* (Deichm.),[1] Grügelborn, Rhenish Prussia.
,, *scaberata* (Gold.), Altenwald, Rhenish Prussia.
,, *Weissiana* (Gold.), Brücken, Rhenish Bavaria.
Anthracoblattina camerata, Kliv., Dudweiler, Rhenish Prussia.
,, *Dresdensis* (Gein.-Deichm.), Klein Opitz, Saxony.
,, *incerta*, Kliv., Dudweiler, Rhenish Prussia.
,, *Lubnensis* (Kušta),[2] Lubná, Bohemia.
,, *porrecta* (Gein.), Weissig, Saxony.
,, *Remigii* (Dohrn), Cusel, Rhenish Bavaria.
,, *Rückerti* (Gold.), Stockheim, Bavaria.
,, *Scudderi*, Gold., Wemmetsweiler, Rhenish Prussia.
,, *sopita*, Scudd., Weissig, Saxony.
,, *spectabilis* (Gold.), Weissig? and Löbejün, Saxony.
,, *Wagneri*, Kliv., Löbejün, Saxony.
,, *Winteriana* (Gold.), Dudweiler, Rhenish Prussia.
Hermatoblattina Kirkbyi (Woodw.), Fifeshire, Scotland.
,, *Labachensis* (Gold.), Labach, Rhenish Prussia.
,, *Wemmetsweileriensis* (Gold.), Wemmetsweiler, Rhenish Prussia.
Progonoblattina Fritschii (Heer), Manebach, Saxe Weimar.
,, *Helvetica* (Heer), Erbignon, Switzerland.
Oryctoblattina Arndti, Kušta, Třemošná, Bohemia.
,, *oblonga*, Deichm., Weissig, Saxony.
,, *reticulata* (Germ.), Wettin, Saxony.
Petrablattina gracilis (Gold.), Labach, Rhenish Prussia.
Leptoblattina exilis, Woodw., Dudley, England.
,, *insignis* (Gold.), Dudweiler, Rhenish Prussia.

III.—On Perlitic Structure.

By W. W. Watts, M.A., F.G.S.

I HAVE received from my friend Mr. W. F. Smeeth a paper entitled "A Perlitic Pitchstone from the Tweed River, New South Wales, with remarks on the so-called Perlitic Structure in Quartz," published by the Royal Society of New South Wales. While thanking him for his courtesy in making me acquainted with his views, I desire at the same time to express my sense of the kindly way in which he has criticized, though often adversely, certain statements already published by me.[3] It may be of interest to give to the readers of the Geological Magazine an abstract of the excellent piece of work which Mr. Smeeth has done, as well as to draw attention to the points in which he has compelled me to agree with him and to remark on those on which there is still some difference of opinion between us.

The glassy matrix of the rock, which is admirably perlitic, contains phenocrysts of quartz, sanidine, albite, and hypersthene. The last mineral is in small distinct grains of prismatic habit, which

[1] *Etoblattina Rollei*, Deichm.
[2] *Blattina* (*Anthracoblattina*) *Lubnensis*, Kušta.
[3] Quart. Journ. Geol. Soc. vol. L (1894), pp. 367–76.

contain inclusions of magnetite, zircon, and apatite, but none of the metallic-looking plates which are so common in this mineral; the magnetite grains, which occur at times in the glass of the rock and at times partly in the hypersthene and partly in the glass, Mr. Smeeth regards as derived from the hypersthene by solution. The presence of this mineral in so acid a rock, one which contains 75·5 per cent. of silica, is a remarkable feature. The bulk analysis shows that more than twice as much potash as soda is present, but the analysis of the matrix, after removal of the phenocrysts, proves that most of the latter oxide is in the glass, of the former in the porphyritic crystals. 1·3 per cent. of soda will be in the sanidine, and 1·9 of lime in the albite. The albite occurs in the glass as straight and forked microlites, the other constituents in the glass being crystallites, mainly in the form of a central axis with two, three, or four rows of globulites arranged along it.

The quartz crystals are traversed by curved cracks, so like those described by myself as perlitic that the author regards them as identical, and it seems to me quite rightly. He remarks, however, that "if 'perlitic' simply implies that a crack is curved and may reasonably be inferred to be due to contraction on cooling, then the majority of these cracks are undoubtedly perlitic," but adds later that he hopes to show "that typical perlitic cracks present well-marked characteristic features, which give them the right to be considered as forming a distinct and definite rock-structure, and which features are markedly different to those exhibited by the cracks in the quartz."

Mr. Smeeth then gives in some detail the method of producing artificial perlites in balsam, and insists on the necessity of using a ground glass surface in order to produce the cracks in perfection. On watching the process under the microscope, when it is allowed to take place slowly, a set of polygonal cracks is seen to make its appearance first, "and then each individual perlite springs suddenly into existence, producing the impression of a tremor in the little mass of balsam. The higher the balsam is heated and the more quickly it is cooled the smaller is the interval of time between the two sets of cracks, until it becomes imperceptible to the eye." It appears, though this is not clearly stated, that the crack begins at the exterior and travels to the interior, an important point being that the crack always tends to be a spiral. Artificial perlites being produced on the flat, Mr. Smeeth next inquires into the nature of the crack-surface in the solid, and shows that the lines revealed by thin sections are either spirals or closed curves resembling circles touching one another tangentially. From this he infers that as a coiled plane cannot possibly be such that all its sections shall be spirals, the simplest case will be where the plane is coiled about a stationary axis, and this case will become more complex when the axis shifts in the course of the growth of the perlite. From what will shortly be said it will be seen that sections of perlites conform to a great extent to these ideals, and Mr. Smeeth's illustrations give admirable examples.

As perlitic structure is by no means of constant occurrence, even in glassy magmas, the author seeks the reason from analogy with balsam and finds it in the friction due to the cooled surface; "doubtless these only occur where there are some particular relations between the strain and the viscosity, or brittleness, of the medium."

Turning now to the 'perlitic cracks' in the quartz, these differences are noticeable: "First, they do not lie in the meshes of a set of polygonal cracks, but on the contrary are often seen to be continuous with some of the polygonal cracks of the matrix. Second, instead of being segmental or touching each other tangentially they are almost invariably closed by abutting abruptly against each other." On the other hand, "perhaps the most obvious characteristic is that the curves constituting a (matrix) perlite never meet otherwise than tangentially, while another striking feature is the fact that the curves are so frequently segmental, the crack ending abruptly in the medium, and even curving round so as to run parallel with an adjacent crack instead of splitting into it." Mr. Smeeth therefore endeavours to imitate quartz cracks and succeeds very satisfactorily by cementing on the ground glass round slips of cover-glass and pouring balsam on both the smooth and rough glass. Then, on heating and cooling in the usual way, it is found that the cracks over the smooth glass are quite distinct from those over the ground glass, and the former present a very strong likeness to those seen in quartz. Anyone who compares the figure of this structure given by Mr. Smeeth on plate xlv of his paper with figure 2, p. 371, and figure 1, plate xviii of mine,[1] will be struck with the obvious points of resemblance between the cracks in quartz and those in the balsam. Unfortunately the balsam figure is not quite sufficiently distinct to institute a very minute comparison, and we cannot be sure that the cracks pass outward from the balsam over the smooth to that over the rough glass; apparently they do not. Again, none of the characteristic ground-glass cracks penetrate into the rest. These features are both very marked in the rhyolite of Tardree. I am, however, truly glad that Mr. Smeeth has shown that there is strong ground for believing that both types of cracks are due to shrinkage on cooling, and that they are the result of a single continuous process acting on the same type of material under slightly altered circumstances, though he does not seem to have followed this idea to its logical issue by indicating that these aberrant cracks will indubitably be produced at times in pure glass, and that such cracks in glass have often been referred to as perlitic. In conclusion the author points out that certain of the cracks described by me as occurring round, and often cutting, quartz grains are probably the result of shrinkage of the quartz alone, and, while cracks are likely to be produced in a homogeneous substance like quartz, he regards it as very unlikely that anything even so far approaching perlitic structure could ever be produced in a heterogeneous lithoidal ground-mass.

[1] *Op. cit.*, pp. 367–76.

I must take this early opportunity of stating that the slides from Tardree which I have examined do not exhibit anything like the perfection of perlitic structure seen in the well-known examples from Meissen, from Mexico, or even in the instances described by Mr. Smeeth, and it may at once clear the issue if I plead guilty to not having used the term perlite in the restricted sense favoured by this observer; my use of the term will be made plain shortly.

The main point that I had before me in writing my paper was this: to show that the fact that the matrices of many lithoidal felsites showed a rude perlitic structure was not in itself absolute and sufficient proof that the rocks had necessarily once been glassy in

Section of Perlitic rock from Jalisco, in Mexico.

texture. I hoped that I had proved the following points: (1) That curved cracks as perfect as those found in felsites occur in quartz and olivine. (2) That these and other curved cracks pass from one class of material to another, in this instance from quartz to glass and *vice versa*, with very slight deviation in direction. (3) That all the types of cracks which make up what I might call the 'perlitic system' of the particular glass in question were to be recognized in the quartz and in most cases passing from glass to quartz.

The first point, I take it, would not be disputed by Mr. Smeeth, although he remarks, and quite correctly, that a careful study would discriminate between the types of curves characteristic of quartz and those spiral ones formed when the structure is most favourably

developed in glass. I may here state that, in a private letter to myself sent just after the publication of my paper, Mr. F. Rutley called my attention to this difference, insisting on the fact that whilst the cracks touched one another tangentially or at a low angle in glass, in quartz the angle was always a higher one. He kindly sent me a beautiful perlitic rock from Jalisco, in Mexico, which illustrates this admirably, and the annexed process-block, prepared from a photograph I took of the slide, will show the feature sufficiently well. However, it also draws attention to the fact that Mr. Rutley's description is a little more accurate, for this particular instance, than Mr. Smeeth's, for many of the circumferential cracks *do anastomose with one another* in a way that cannot be explained by the tangential touching of excentric circles. Indeed, so far as my experience goes, the cracks in glass rarely or never reach the high perfection of those in balsam.

With regard to the second point, so far as I am able to judge from his figure (*loc. cit.*, pl. xlv, fig. 4), I do not observe that there is much tendency in the artificial production of 'quartz perlites' for the cracks characteristic of one type of material (or method of production) to invade the neighbouring material.

In describing the Tardree rhyolite I used the term perlitic structure in a rather wide way to include the whole system of contraction cracks which are linked up by a common mode of origin. The following types of fissure were recognized: (*a*) polygonal cracks; (*b*) curved cracks; (*c*) radial cracks running approximately perpendicular to the polygonal fissures; to these I would now add (*d*) other radials joining one or two curved cracks with each other. Rarely only one of these types is present at a particular point of a slide, usually two or three, and occasionally all four types are present in one matrix perlite.

Taking these types in order and referring to the figures and plate given with my paper,[1] it will be seen that type (*a*) is present in quartz and matrix, type (*c*) in the latter and sometimes in the former (pl. xviii, fig. 3), and type (*b*) is ill developed in the matrix and absent from the quartz. Fig. 5 on the same plate gives a matrix perlite with curved (spherical or spiralloid) cracks (*b*) and radials (*d*) enclosed in a network of polygonal cracks (*a*); all three of these types of fissure traverse the quartz, two of them at least passing in from the matrix. Guided by the example of the balsam one would suppose that the polygonal cracks were the oldest and practically simultaneous in both constituents; the curved ones would follow, and, beginning in the glass, would cross the quartz and finish off in glass. In this case the whole system seems to be bound up in the two constituents.

Fig. 6, pl. xviii is a case in which the polygon enclosing a perlite is completed in quartz, and two radials at least of type (*c*) spring from that part of the crack which crosses the quartz. Again, if we agree with Mr. Smeeth that in such examples as those figured in figs. 3, 5, and 6, p. 370, and in pl. xviii, figs. 1 and 2, the cracks

[1] *Op. cit.*, p. 371 and pl. xviii.

are due to the contraction of the quartz and the direct strain thus brought to bear on the surrounding glass, we cannot but notice that these cracks undergo no change in direction or character when traced into the glass. So much is this the case that I think it would be very difficult for anybody to tell from the plate, the drawing, or the photograph, even indeed from the examination of the slide itself except in polarized light, where the quartz ends and the glass begins, so exactly alike are the cracks in the two substances; for this reason a small drawing (fig. 1*a*) was added to plate xviii.

There seems to me to be no reason why the two types of curved cracks which mainly characterize the quartz and matrix respectively should not be regarded as distinct, and even receive separate names; but it will have to be borne in mind that the quartz types can be artificially produced in structureless balsam, that they extend from quartz to matrix, and that they must undoubtedly occur independently in glass; and also that, on the other hand, the perlites of the type more characteristic of glass are often completed in quartz with little or no change in character. The main fact still remains untouched, that rectilinear and spherical contraction cracks indifferently traverse two distinct constituents of the rock, and that the 'little rift' is not solely the fault of either of the 'contracting parties.'

IV.—The Copper Deposits of Michigan.[1]

By M. E. Wadsworth, Ph.D.,
Director of the Michigan Mining School.

In looking at the map of the Great Lake region, you have all noticed the backward bending thumb of Michigan projecting into the icy waters of Lake Superior; yet but few of you, perhaps, have realized that extending along that thumb there runs a band or ring of native copper. It does not, like most gold or silver bands, extend around the finger, but along it—from the base of the hand to the end of the thumb—this central band lies embedded in the flesh binding all together. Shall we now dissect it, laying bare its flesh, muscle, and bone, and try to explain its marvellous organization?

To do this, it will be necessary to drop much of our simile and to make as clear as possible the geological structure of the district in question. Roughly, its central portion, extending from the south-west to the north-east, may be said to be made up of an elevated plateau, bearing upon its wrinkled surface protuberances or hills—locally called mountains—like warts upon a finger. Flanking both sides of this higher land lie lower lands extending down to the level of the lake. This lower level is formed of hardened beach muds, sand, and shingle, laid down on the shores of a tide-washed sea. We find in it the ripple marks made by the waves, the mud cracks formed when exposed to the drying sun, and the prints of the soft

[1] Read at the Annual Convention of the Michigan Bankers' Association, September 12, 1895.

raindrops that fell, at ebb, upon the gently sloping beach. This formation is known to you all through its affording the beautiful Portage Entry or red sandstone (Devonian), so much used now in building. It is, however, with the central higher or plateau region that we have the most to do with at present.

You are all familiar with the descriptions or with the sight of the lava beds of Vesuvius, or of Etna, or on Iceland, or on the Sandwich Islands. You know how the lava flows onward towards the sea, now rolling with a rough, ropy, clinkery surface; and now gliding with a comparatively smooth one. This Lake Superior plateau is composed of a series of lava-flows like those of Kileaua, generally smooth but sometimes clinkery. Let us imagine a large sheet of ice extending over a lake—when from some cause a long fissure rends it open on one side, and the water wells up through the sheet and overflows the icy expanse. This overflow congeals; the ice is again rent in twain; a new overflow takes place, and so on until the ice continually sinking is piled up in successive thicknesses, hundreds or thousands of feet.

Let us now more exactly explain what has taken place in Northern Michigan. The present promontory of Keweenaw Point once formed the gently sloping tide-washed shores of a sea. Over this shore poured the vast floods of lava, the same kind as now flows out from Etna, Kileaua, and the majority of active volcanoes of the present day. These flows, like those of Kileaua, were apparently quiet, and not explosive like those of Vesuvius and Etna. At the time of the outpouring of these vast floods of lava, the shores were gradually sinking so that the congealed rock was exposed to the action of the sea-waves.

You all know of the effect of the storm-dashed waves upon a rock-ribbed coast—how the rock is torn down and worn away, and then piled up along the shores as a resulting mud, sand, gravel, and shingle. In like manner our lava-flows, along the shores of that great northern sea, where Lake Superior now is, were subject to the alternate tide and storm-waves, and to the action of sun, rain, wind, and frost. The result of all this must have been that the exposed portions of these flows were buried under their own débris, mingled with that of associated rocks. Besides the lava-flows before mentioned we find other flows and masses, similar in chemical composition to our granites, which, being much harder and more enduring than the basaltic lavas, make up by far the larger portion of the débris now visible.

This region, then, is composed of a series of interbedded basaltic lava-flows, with their associated shingle, sand, and mud now forming conglomerates, sandstones, and shales.

In order to show more clearly what has happened since, let us take a new metaphor, and look upon all these layers as forming a sort of marbled cake. Now let this cake be cut lengthwise along one side of the thumb-like mass, the cut extending north-east and south-west, nearer to the south-eastern side. Consider that the north-western part has been lifted up at a varying angle from

30° to 60°, and also cut across by fissures running north-west to south-east, and you have a fair idea of what has happened.

It is well known that in all regions where volcanic forces have been active, that when these forces die out, hot-water action is one of the last results, the waters gradually growing cooler until they are at the normal temperature, so that in time there is no evidence of the former hot state except that shown by its results on the rocks.

In the Lake Superior district the water action—mostly hot, sometimes cold—was strongly marked during the fissuring and movement, or, as it is technically termed, "faulting" of the rocks, as well as for a long time subsequently. During the time of this water action all the rocks, without exception, were penetrated by these percolating waters, much of their materials dissolved out, or chemically re-arranged, or removed and replaced by other elements. It was then that the native copper now found in the rocks was stored up on its present banks of deposits, from which it is now being rifled by means of the drill, sledge, and dynamite. Three different systems of local deposit have been employed by Dame Nature on Keweenaw Point. The profound and repeated fissuring previously spoken of caused huge vaults to be made where the percolating waters left, securely locked up, their treasures of copper; and here the largest single deposits were made, and the drafts have been fully honoured. The vaults extend mainly in a north-west and south-east direction, cutting across the country. These deposits are technically known as fissure veins; and as examples there may be cited the Central, Cliff, Phœnix, and other mines, mainly on the northern end of Keweenaw Point.

As one would naturally suppose, the various lava-flows would differ in thickness, owing to the varying amounts of volcanic material erupted, as well as to the inequalities of surface. Like variation would also exist in the extent and amount of deposited conglomerate, shale, and sandstone, on account of similar inequalities of the surface during its formation, and the area exposed to the tidal or wave action.

Returning to the lava-flows, it has been found that the thinner ones are more glassy, and hence more easily acted upon by the percolating waters; thus, large amounts of the original rock materials have been dissolved out, removed, and their places, as well as those of all other cavities, have been filled with deposits of copper and other mineral matter. These deposits are mined and form the melaphyre (locally called amygdaloid) mines, such as the Quincy, Osceola, Franklin, Atlantic, and Huron. These mines are worked on old lava-flows that have been impregnated with copper, the same as a flow from Mount Etna might be worked, if it were likewise filled with valuable mineral. Although it is usual to speak of these mines as worked upon veins this is an error, as they have neither the structure of a vein, nor any sign of a vein about them. They are simply flow deposits.

At the same time our fissure, or vein, and overflow deposits were

formed, similar deposits were made in the interbedded detrital or sea-beach materials, or conglomerates. Here the percolating waters removed much of the cementing mud and the more easily soluble pebbles, filling in the places thus left with copper and other mineral matter. This form of deposit gives rise to our conglomerate mines, such as the Calumet and Hecla, Tamarack, Peninsula, and Allouez.

These mines are not worked upon veins, but upon old sea-beach shingle, the same as if any one of your beaches here, after having been covered up, should be worked for any mineral matter. They are not veins and they have no sign of a vein upon them; but they are simply bed deposits.

You may ask, whence came the copper now deposited in these three different kinds of safety vaults—vaults that were found by pre-historic man to be thoroughly fire-proof, but which are not burglar-proof, when attacked by the modern earth-robber with power drill and dynamite? No one can tell whence came this copper; he can only infer.

The largest amounts of copper are generally well within the series of lava-flows, and associated with or underlying the thicker and heavier beds. Further, it has been seen that the general course of the copper was downwards, as it extends frequently like icicles, from the overhanging bed into the one that is worked, while sheets of it are wrapped around the angles of the broken blocks, like paper around a grocer's package. These and numerous other facts show that the copper was deposited from water subsequently to the fracturing and faulting of the rocks; and that it was probably originally disseminated through the lava-flows, and has since been concentrated in the various banks of deposit by the percolating waters, which penetrate all rocks.

Did time permit, the evidence in behalf of all the statements made here could be laid before you: these evidences are picked up one by one by the earth's detectives, the geologists, who, like the Sherlock Holmes's, study the ashes, the mud, and every relic left by that thief, Time, in the depositories of old Mother Earth. As you read the story of each coin and bill, each check and draft, so we read the story of each pebble and rock; and learn to ferret out the secret deposit of Dame Nature.

V.—Recent Coast Erosion at Southwold and Covehithe.

By John Spiller, F.C.S.[1]

THE sixteenth of May last was a disastrous date for Southwold and the neighbourhood, for, owing to the prevalence of northerly winds on this and the two previous days, culminating in a moderate gale, the tides rose to an abnormal height, and this, combined with a rough sea, made fearful inroads upon the soft, sandy cliff and the shingle on the foreshore, washing away a large piece of land and creating a new cove at the northern boundary of the little town. The effect would have been worse but for the

[1] Read before Section C at the Ipswich Meeting of the British Association, 1895.

existence of a clay-footing and promontory at the extreme point, and two immense concrete blocks constructed a few years ago to act as a breakwater and give protection to this part of the cliff. These latter proved of temporary service, but became so shattered and disintegrated that they must be replaced, or a sea-wall built, to resist further inroads at the next high-flowing tide. Similar erosion has occurred on the face of Easton Bavents cliff and at Covehithe, and it is feared that the loss of land at those places will render Southwold all the more assailable in future. Upon two occasions during the winter of 1894–5 (December and January) the tide rose to even greater height, and inundated large tracts of salt-marsh around Southwold, making two ruptures in the railway embankment and stopping the trains for a few days, but as there happened fortunately to be no wind at the time the damage done to the sea-front was confined to the sweeping of the shingle further south, with comparatively little damage to the cliffs of Southwold. It became necessary, however, to remove all the boats and capstans from the beach and pull them up the cliff or drag them inland; and this had again to be done on the 15th and 16th May.

The Barometric and Weather Record for Southwold, as entered on the Royal National Lifeboat Institution's chart for the middle of May (8 a.m.) is as follows:—

1895.	Bar. in.	Direction and force of wind (0 to 12).		
May 13.	30·25	S.W.	3.	Gentle breezes, sunshine.
14.	30·25	N.E.	2.	Light breeze, sultry.
15.	29·9	N.	5.	Fresh breeze, gloomy.
16.	29·6	N.	7.	Moderate gale, cloudy, rain, snow, and hail.
17.	29·5	N.N.W.	6.	Strong breeze, ugly threatening weather.
18.	29·4	N.E.	4.	Moderate breeze, cloudy.

It was remarked that with a fresh breeze, northerly, on the 15th, the ebb tide was cut short or intercepted, and then came the gale which did the damage with vastly augmented tide on the 16th May. These are the conditions generally recognized on the East Coast as demanding watchful care on the part of the seafaring population, so that the event was anticipated and preparations made, as far as possible, to cope with the incoming tide on the second day. No injury was sustained by the fishing-boats, nor on the greater part of the sea-front—Centre Cliff and Gun-hill—which are protected by a sea-wall; but the North Cliff, not being so secured, suffered to the extent described; and a repetition of northerly gales and high winter-tides may be expected to do further mischief until the precautionary measures, for which Parliamentary sanction is required, are carried out in the coming year, either by prolonging the existing sea-wall or constructing an efficient breakwater at the northern extremity of the town.

The Memoir of the Geological Survey, by Mr. Whitaker, explanatory of "The Geology of Southwold and of the Suffolk Coast from Dunwich to Covehithe," may be consulted with advantage by those desiring information on this all-important subject; and the waste of the coast during recent years is therein fully described. Thomas Gardner's map and historical account of Dunwich, dated

1754, Saxton's map of 1575, and earlier records, prove how great has been the loss since that town was the capital of East Anglia, and boasted of its mint and numerous churches, only one of which, All Saints, and the adjoining monastery, now both in ruins, yet remain on the high cliff as sole survivors of its ancient grandeur. Covehithe Ness has worked back about two miles; Easton Bavents about as much, and is no longer the most easterly point of England. Southwold also has lost nearly a mile. The coast-line, instead of showing a bold promontory at Covehithe and Easton, is almost reduced to a straight line on the present Ordnance Map, and the designation "Sole Bay" has thus become a misnomer, the northern limit being destroyed.

But to return to Southwold proper, and estimate the loss of land there by recent coast erosion, I have had the advantage of professional assistance kindly rendered by Mr. Eaton W. Moore, Surveyor and Land Agent, who has lived in Southwold nearly all his life, and remembers the sweeping away, in March 1862, of the coastguard house and beach-cottages which formerly stood on the shore below the East Cliff and Centre Cliff. This gentleman has measured the inlet, which I now propose to call North Cove, and gives me the following dimensions, viz.: 148 feet long by 60 feet mean depth, equal to 8880 square feet, or, roughly, one-fifth of an acre. And, if we add to this the loss of contiguous roadway, near the fishermen's huts, amounting to $396 \times 32 = 12{,}672$ square feet, we arrive at a sum total of 21,552 square feet, equal to *about half an acre*, of land actually washed away by the recent high tide. Not only is territory diminished to this extent, but there has been a great drifting away of loose shingle from the back of the shore, so that the path left remaining is "terraced" from four to six feet above the beach-level, instead of forming a gentle gradient from roadway to sea, as was the case prior to May 16th. By the removal of this thick shingle-bed and the erosion of the face of the cliffs beneath, the sections of Boulder-clay, sand, and loam, with a little bit of black peaty bed, and one or two pockets of shelly crag, have come prominently into view. A human skeleton also was found buried in a superficial accumulation made up partly of reassorted Boulder-clay, which at first was thought to be prehistoric, but this has been taken in hand by Mr. Walter Mawer,[1] and submitted to Dr. Garson and Mr. E. T. Newton, with the result that its primeval claims have been finally disposed of, and the cranium held to be that of a low, but ordinary, type of current humanity.

As if to compensate for the town's loss, the shingle-beds both to the north and south of Southwold have been considerably raised, and spread over a wider area of the marshes. This is apparent all round the "rocket staff" marked on the Ordnance Map, and the "brickmakers' pond" has also been partially filled up; moreover, another ditch, approached by a gate through which I passed last year, is now firmly silted up. A breach has likewise been made, to the extent of 74 feet, at the northern end of the straight dyke

[1] "The Southwold Skeleton": *East Anglian Daily Times*, June 7th, 1895.

wall indicated on the map as running north-east from the shore extremity of Buss Creek. This was broken through by the force of the incoming waves, and much shingle deposited in and behind the said beach. Much silting up also has occurred in front of Easton Broad, and in the two hollows that the pedestrian passes on his way there by the Easton Cliff, as indicated in the coloured plate, "Sections of Suffolk Cliffs," appended to Mr. Whitaker's Memoir. At the hollow close to Easton Broad the accumulation of shingle has all but exterminated the yellow-horned poppy, which was growing there in profusion last summer; and, of course, the channel or outlet to the sea, ever changing, was affected, and for nearly three months it became impossible to walk to Covehithe along the shore without wading through the watercourse, in which, by the way, I picked up (in June) a rounded lump of red hæmatite iron ore weighing 1 lb. Early in August this channel was again blocked, so that the way to Covehithe along the beach is once more restored.

Whilst all these changes have occurred, it is also manifest that the lines of high and low watermark have sensibly altered, so that in this respect the Ordnance Maps will need to be corrected by a fresh survey, and the configuration of the coast-line somewhat modified. The North Cliff bathing-station had to be moved, and the Gun Battery at Easton shifted back 34 feet; and further north the old path is seen in many places to lead over the edge of the cliff. In August last Mr. Horace B. Woodward and I carefully measured several spans of wasting cliff, the records of which were noted by Mr. Whitaker on his field copies of the Ordnance Map as having been taken by himself in 1882 and 1889. Here are the details for comparison:—

I. *Easton Bavents.*—"550 feet from hedge to cliff-top, at hedge on south-west of road. June 1889. Buildings gone. W. W."

This is now 530 feet. August 1895.

Loss in six years=20 feet.

II. *Easton High Cliff.*—"Edge of cliff from hedge running north and south, 130 feet. W. W. May 1882."

We found this to be 108 feet. August 1895.

Loss in thirteen years=22 feet.

III. *Covehithe Cliff.*—The distance from the hedge on the south side of the road, between the coastguard station and the cliff-top, was ascertained to be 90 yards in June 1889, by Mr. Whitaker.

Our measurement on 16th August, 1895, was 62 yards.

Loss in six years=84 feet.

Other observations and measurements made by us show that the general loss on Covehithe Cliff since the Ordnance Map was constructed (1882–3) has been about 50 yards.

The rate of demolition at points along the coast between Southwold and Covehithe appears, therefore, to vary considerably, and one is content to record the facts and figures for future use rather

than proceed to draw inferences as to *annual rates of loss* from these recent observations.

To complete my tale, I should mention that the heavy rains of July last had a further disastrous effect upon the new faces of sandy cliff at Southwold, and again much loosened material has fallen, but this time not by direct marine agency. The worst feature of the case is the delay attendant upon Parliamentary proceedings to obtain the necessary sanction for carrying out the protective works, as another winter must inevitably intervene before they can be put in hand, and no temporary expedients of a satisfactory character have been suggested.

[The paper was illustrated by photographs and a water-colour sketch of the new cove at Southwold.]

VI.—The Southern Character of the Molluscan Fauna of the Coralline Crag Tested by an Analysis of its more Abundant and Characteristic Species.[1]

By F. W. Harmer, F.G.S.

THE close resemblance between the Molluscan fauna of the Coralline Crag and that of the Mediterranean at the present day has long been known and is universally recognized. It has been customary, however, to take the whole list of shells from this deposit, for the purpose of comparison, without reference to the greater or less abundance of the different species; but in discussing the affinities of the fauna from this, or indeed from any other horizon of the East Anglian Crags, it may be misleading to attach as much importance to the presence of a shell, of which only one or at the most a very few specimens have been discovered during so many years, as to the occurrence of forms which are found in such countless profusion as sometimes to compose a large proportion of the whole number of the shells present. Out of about 440 species of Mollusca from the Coralline Crag given by Mr. Wood in his well-known Monograph[2] (excluding varieties), nearly 90 are said to be represented by unique specimens only, while more than 100 others have very rarely been met with. It is true that some of these rarer forms may be only locally rare, although it is worthy of notice that, with few exceptions, the species which are common in the Diestien beds of Belgium,[3] believed to be approximately contemporaneous with the Coralline Crag, are also common in that deposit. On the whole, without ignoring altogether the existence of the rarer forms, it seems that a consideration of the general facies of the fauna of each of the different horizons of the Crag, and of its characteristic fossils, is more important and is likely to give more reliable results than an analysis of all the species of each bed, irrespective of the greater or less frequency with which they have been found.

[1] Read before Section C of the British Association at Ipswich, Sept. 12th, 1895.

[2] Palæontographical Society (1848, etc.).

[3] Van den Broeck, Introduction au Mémoire de M. P. H. Nyst sur la Conchyliologie des Terrains tertiaires de la Belgique. Bruxelles (1882).

The Southern character of the Molluscan fauna of the Coralline Crag and its exceedingly close resemblance to that of the Mediterranean is much more clearly shown when we take its abundant shells only as the basis of our analysis. Omitting from Mr. Wood's catalogue varieties, and those forms which are represented by unique specimens only, or which are very rarely met with, we have about 220 species which may be regarded as the representative shells of the formation. Of these 82, or about 37 per cent., are not, according to Mr. Wood, known to be living, and seven others may be, for our present purpose, regarded as extinct, as they have ceased to exist in European seas, and are only now found in distant parts of the world. Of the 132 species remaining, 119 occur in the Mediterranean at the present day, and twelve others in what Dr. Gwyn Jeffreys has called the West European area—that is, along the Atlantic coasts between the Straits of Gibraltar and the English Channel—provinces which he says cannot be regarded as zoologically distinct. There is thus only one among the characteristic Mollusca of the Coralline Crag, viz. *Buccinum (Buccinopsis) Dalei*, which does not live in seas to the south of the British Islands, and this species cannot be regarded as undoubtedly boreal, for it is given by MM. Dollfus and Dautzenberg, with a (?) however, as occurring in the Miocene beds of Touraine.[1] Mr. Wood, analyzing the entire list of Coralline Crag shells, gives 20 as British and not Mediterranean; but of these, 15 are very rare, and the others, with the exception of the species just named, are West European. The close connection between the fauna of the Coralline Crag and that of the Mediterranean is further shown by the fact that more than 30 of the *extinct* species of the former are said to occur either in the Pliocene beds of Monte Mario, near Rome,[2] or in those of Biot, near Antibes, in the South of France.[3] As to the Monte Mario beds, Sig. Ponzi and Meli remark that their Molluscan fauna would be identical with that of the Mediterranean at the present day were it not that some species have emigrated and some have become extinct. Out of 396 species of Mollusca found at Monte Mario, given in a list published by Cav. Zaccari,[4] more than 150 occur also in the Coralline Crag, a larger number than is common to the latter deposit and the Diestien beds of Belgium, contemporaneous deposits of the Anglo-Belgian Basin not more than 150 miles apart.

These facts—the close correspondence between the recent Molluscan fauna of the Coralline Crag and of certain Italian Pliocene beds with that now living in the Mediterranean and the West European areas, and the resemblance of these deposits, palæontologically, to each other—seem to point, not merely to the conclusion that there must have been free and direct communication between the sea of the Coralline Crag and the Atlantic, but also that at some period

[1] Étude préliminaire des coquilles fossiles des Faluns de la Touraine. Rennes: Paris (1886).

[2] Ponzi and Meli, Mem. R. Accad. dei Lincei, ser. 4, vol. iii, p. 672 (1887).

[3] A. Bell, Catalogue des Moll. Foss. des Marnes Blues de Biot, près Antibes: Journ. de Conch. Paris (1870).

[4] Zaccari, Catalogo dei Fossili del Monte Mario, Collezione Rigacci. Roma.

subsequent to the coming into existence of the present fauna there was more open connection between the latter and the Mediterranean than there is at present. The distinctively Southern character of the fauna of the Coralline Crag is further shown by the comparatively large proportion of its shells that do not now live so far to the north as the seas of Great Britain, but this also comes out more strongly when we confine our attention to its more abundant forms. While, as has been shown, there is only one among the 132 recent European Mollusca, representative of the formation, which is British and not Southern, there are 35, or 26 per cent., which are Southern and not British. But among the forms usually regarded as British, there are nine—viz.: *Cerithium Metaxa*, *Cæcum trachea*, *Modiola rhombea*, *Limopsis aurita*, *Scacchia orbicularis*, *Woodia digitaria*, *Donax politus*, *Thracia pubescens*, and *Poromya granulata*, characteristic shells both of the Mediterranean and of the Coralline Crag —which are either confined to the south-western portion of our seas, or have been included in lists of the British fauna because of the occasional discovery of some rare specimens on our coasts. If we regard these nine species as Southern, we have 44 out of 132, or more than one-third, which are Southern and not British. In a word, the abundant shells of the Coralline Crag which are now living in European waters are practically all Southern forms, though some of them range also into Northern seas, but the few shells which are exclusively boreal are, with the one exception named, exceedingly rare. It may safely be said that if it were possible to count shells instead of species, we should meet with some thousands of specimens of recent Southern Mollusca in the Coralline Crag for every recent boreal shell we could discover. We find also among the *extinct species*, abundant in the Coralline Crag, a greatly preponderating number of *genera* of a decidedly Southern character. Among these may be mentioned, *Voluta*, *Terebra*, *Cassidaria*, *Pyramidella*, *Nucinella*, *Scintilla*, *Erycinella*, *Panopæa*, and *Pholadomya*, the last of which is tropical, as is also the West Indian shell, *Erato Maugeriæ*, and both these are abundant.

On the other hand, no shell, in Mr. Wood's opinion, of an exclusively Arctic character has been discovered in the Coralline Crag, except a single valve, which he referred with a good deal of doubt to the species *Cerithiopsis lactea*; but among the extinct forms there is one, *Glycimeris angusta*, which is not uncommon, which belongs to a Northern genus.[1] Attention has been called to the profusion of the different species of *Astarte*, as giving a boreal

[1] Professor Prestwich gives a list of about a dozen species of Mollusca which he claims as Northern (Q.J.G.S., vol. xxvii, 1871, p. 135). Five of these, however, range to the south as well as to the north of our shores; and as to the rest, with the exception of the one already named (*Buccinopsis Dalei*), and another, *Trichotropis borealis*, which is very rare in the Coralline Crag, he follows Dr. Gwyn Jeffreys in considering shells regarded as extinct by Searles Wood and others as varieties merely of existing species. For example, he believes *Astarte Omalii* to be the equivalent of *A. undata*, an American shell, and *Tellina obliqua* that of *T. lata*, an entirely distinct form. Mr. Wood had the opportunity of weighing Dr. Jeffreys' views, and he has given in the Supplement to his Monograph his reasons for differing from them. I agree with Mr. Clement Reid and others in following Mr. Wood's opinion as to this.

facies to the fauna of the Coralline Crag. At the present day this genus undoubtedly is characteristic of Northern latitudes, but it is not confined to them. In the Eocene period, as Mr. Wood points out, four species of *Astarte* lived in these latitudes, in association with animals and plants of a tropical character. The *Astartes* of the Coralline Crag are all extinct, except two, which are Mediterranean species; and their occurrence, therefore, does not, I think, present any insuperable difficulty in the way of our accepting the strongly preponderating evidence that the climate of the period in question was considerably warmer than that of the present day.

SUMMARY OF THE ABUNDANT AND CHARACTERISTIC SPECIES OF MOLLUSCA OCCURRING IN THE CORALLINE CRAG.[1]

Not known as living ... ... (37 per cent.)		82
Living in distant seas—Pacific	3	
,, ,, Atlantic	1	
,, ,, West Indian	1	
,, ,, South African	1	
,, ,, North American	1	
		7
Living in the Mediterranean	119	
Not living in Mediterranean, but in West European area	12	
		131
Not known to range to the south of British seas ...		1
		221

Species of European Mollusca abundant in Coralline Crag.

Southern and not British... ... . (26 per cent.)	35	
British (rare) and Southern	9	
(32 per cent.)	—	44
British (characteristic) and Southern		87
British and not Southern...		1
		132

Professor Prestwich, it is true, does not admit this view of the case, and claims that ice action had come into existence even at the commencement of the deposition of the Coralline Crag, resting his opinion on the fact that a water-worn block of porphyry was found in the basement bed at Sutton, which he considers must have been transported, either from Scandinavia or the Ardennes, by floating ice.[2] I differ with considerable reluctance from so eminent an authority, but I cannot help feeling that the evidence of this one block is insufficient to support the theory built upon it. No ice reaches our shores at the present day either from Norway or Belgium, and the winter temperature of Northern Europe would have to fall considerably before this could happen. The almost entire absence of recent Northern shells from the Coralline Crag, moreover, seems to imply either that the sea of that period was not open to the north, or that the temperature of the seas of Scandinavia were affected, as they are now, but to a greater extent, by the Gulf Stream; while as to Belgium, I am not aware that similar ice-borne débris occurs in the Crag beds of that country, nor are such boulders found in our own Red Crag, the climate of which

[1] The figures now given are slightly different to those originally stated, but the conclusions to be drawn from them are not affected by the alteration.

[2] Q.J.G.S., vol. xxvii, p. 134 (1871).

was colder than that of the Coralline. The occurrence of this one block, which was neither angular nor striated, and which might have reached its resting-place in some other way,[1] does not seem to me to justify the otherwise improbable hypothesis of floating ice during any part of the Coralline Crag period. The affinities of the Molluscan fauna of these deposits is clearly with the seas of Southern Europe, or even, as Mr. Wood suggested, of the Azores, rather than with those to the north of the Island. At the present time there is a difference of not less than 10° F. between the average yearly temperature, both of the atmosphere and of the ocean, in the British and Mediterranean areas.

VII.—Notes on Petrological Nomenclature: Schist, Slate, Phyllade, and Phyllite.

By A. R. Hunt, M.A.

In 1891 Professor A. H. Green wrote an interesting notice of two books, both of extreme value to the petrological student, viz. Cole's Aids in Practical Geology and Hatch's Introduction to the Study of Petrology. In the course of his review the Professor remarks: "In dealing with the foliated rocks, the author touches on the debated point of the 'true schists.' We are pretty well used to this phrase, and have waited long in the hopes of being told what constitutes a 'true schist,' but our patience has not yet met with the reward it merits. The author is of opinion that 'the alleged distinction between schist-like rocks and schists of pre-Cambrian age requires great delicacy of definition.' This is delicately put, and will command the assent of most geologists" (Nature, vol. xliv, p. 26).

In the following paper an attempt has been made to ascertain the different meanings attached by authors of repute to the terms Schist, Slate, Phyllade, and Phyllite. All the petrologists quoted are cited as authorities of equal value, and as evidence of the meanings actually current as to different technical terms at the time of writing. No attempt is made to show that one is more correct than another, nor is there any suggestion of such a thing. Webster's Dictionary is quoted, not as an authority on technical terms, but as the glossary of easiest access to the ordinary reader. Webster's definitions may be taken to be the interpretation of scientific terms as popularly accepted.

Schist, Slate, Phyllite, Foliation.—The confusion that has arisen in the use of the foregoing terms is due to the same words being used by geologists in two or more different senses.

Schist and slate are etymologically identical, absolutely synonymous and interchangeable. Both terms signify rocks that split. De la Beche commonly used the word slate, to the entire exclusion of schist. He tells us how a deposit of quartz, felspar, and mica would become gneiss; "while one formed only of grains of quartz and mica would become mica slate" (Geol. Obs., p. 705).

[1] Mr. C. Reid mentions that in some of the Coral islands of the South Seas, boulders which reach the shore on drift-wood are the perquisite of the chiefs.

Much perplexity has been caused by De la Beche describing gneiss among the South Devon metamorphic rocks; but, taking his own definition of that rock, it is not uncommon. If a rock composed of quartz and mica may become a mica-slate, the term slate clearly refers to structure and not to composition, as quartz is in no way argillaceous—the modern idea of a slate. If we turn to recent textbooks we find the meaning attached to "slate" entirely different from De la Beche's. For instance, Jukes-Browne tells us that a slate is "any argillaceous rock exhibiting well-marked cleavage" (Phys. Geol., p. 295); while Rutley describes clays, shales, and slates as "impure hydrous silicates of alumina" (Study of Rocks, p. 282).

Thus the idea conveyed to De la Beche by the term slate is that of the original word, the old English "sclate," a shiver or splinter, whatever the composition. The modern idea is an aluminous rock more or less cleaved, which De la Beche would have probably called a clay-slate.

The term "phyllite" presents even greater difficulties. According to Humble, it is a petrified leaf (Dict. Geol. and Min.). Webster, on the authority of Dana, defines it as "a mineral consisting chiefly of the hydrous silicate of alumina, iron, and manganese [*sic*], and occurring in thin scales or leaves." According to Bristow (Glossary of Mineralogy), phyllite is a magnesian mica, and a variety of ottrellite. Dana tells us that "phyllite occurs in the schist of Sterling . . . . Massachusetts, ... and the rock in consequence of it is called by Hitchcock 'spangled mica slate,' the phyllite being the mica of the schist" (Syst. Min. 1881, p. 506). On examining the analysis, phyllite proves to be a magnesia-potash-mica, manganese being an obvious clerical error.

The popular acceptation of the term phyllite founded on Dana is that it is a mineral, and a species of mica. English geologists, on the contrary, almost without exception, use the term phyllite to define a species of rock. Sir A. Geikie tells us that "by increase of its mica-flakes a clay-slate passes into a phyllite" (Class Book of Geol., p. 223). According to Jukes-Browne, phyllite is "a glossy slate, the metamorphism of which has probably been carried a little further than usual" (Phys. Geol., p. 296). Miss Raisin defines it as "a slate in which a large amount of microlithic mica is developed" (Q.J.G.S., vol. xliii, p. 717). Prof. Bonney speaks of a certain mineral in slate as "one of the hydrous micas which seem common . . . . to the phyllites" (Q.J.G.S., vol. xl, p. 17).

It is clear that the above authorities are at one in considering that a phyllite is a sort of slate. Phyllites pass into schists, for we find a rock described by Teall as "a schistose spotted rock intermediate between a phyllite and a mica-schist" (Proc. Somerset Arch. Soc. 1892, p. 211).

Phyllade is used by some geologists in lieu of phyllite. Professor Cole tells us that "minute mica scales may develop along the cleavage planes [of slate], and a wrinkling of the latter at the same time produces the link with mica-schist, called 'phyllade' by

D'Aubuisson" (Aids in Practical Geol., p. 256). In Lyell's Glossary we find—"Phyllade, D'Aubuisson's term for clay-slate, from φυλλας, a heap of leaves" (El. Geol. 1865, p. 727). Thus, according to Lyell, phyllade is a clay-slate; according to Cole, a link between mica-schist and slate, with a peculiar wrinkled structure.

A mineral often mentioned in connection with phyllite (anglice), is hydrous mica. Professor Judd, however, speaks slightingly of these micas, stigmatizing them as "so-called hydro-micas" (Proc. Roy. Soc., vol. lvii, p. 392).

It is almost certain that by "phyllite" geologists usually mean a rock in which mica has been developed *in situ*, and not slaty rocks in which the mica is detrital. For the latter there seems to be no term but micaceous slate, with all its uncertainties. It may be observed that on one occasion I sent a rock to a friend who described it as a phyllite; subsequently another specialist examined the same specimen microscopically, and pronounced the mica detrital.

But to return once more to the schists. We may dismiss at once the original meaning of a merely cleaved rock synonymous with slate, though on reading De la Beche it is essential to bear the latter definition in mind. According to Dana, "*slate* is an argillaceous rock breaking into thin laminæ; *shale* a similar rock, with the same structure usually less perfect, and often more brittle; *schist* includes the same varieties of rock, but is extended also to those of a much coarser laminated structure. The ordinary clay-slate has the same constitution as mica-slate. . . . . The two pass into one another insensibly" (Dana, Manual of Mineralogy, 1864, p. 357).

"Shale" has somewhat fallen into desuetude, but it is sometimes used for rocks which split in the planes of bedding, and not in planes of cleavage.

Webster describes schist as a rock having a slaty structure. Slate might with equal truth be described as a rock with a schistose character. Lyell tells us that mica-schist "passes by insensible gradations into clay-slate," which latter rock we are further informed is common to the metamorphic and fossiliferous series (El. Geol., p. 726). Daubrée writes of clay-schists (schistes argilleux) and slate-schists (schistes ardoisiers)—(Geol. exp., p. 398). A very concise definition of schists is that of Mr. Jukes-Browne, viz., "foliated rocks splitting into thin layers of different mineral matter" (Phys. Geol., p. 296).

Professor Bonney defines the term schist with much precision: "I apply the term schist only to *foliated* rocks. . . . . The lax use of the term by many Continental and some English petrologists (by whom it is made to include not only highly metamorphic rocks, but also some where the chemical and mineral changes are but slight) causes much confusion" (Q.J.G.S., vol. xl, p. 4).

In the above definitions of "schists," a new source of trouble is introduced in the word "foliated." One might suppose that the typical foliated rock would be the one like a "heap of leaves," *i.e.* a phyllade; but technically a phyllade is the very type of a non-foliated rock.

We now turn to Webster to ascertain the popular scientific meaning of "foliated." We find it to be "restricted to the variety of laminated structure found in crystalline schist." Now, if in Prof. Bonney's definition we substitute "crystalline schist" for "foliated rocks," it would read: "I apply the term schist only to crystalline schist"; and this, so far as I can ascertain, is the view accepted by British petrologists. If we are careful to remember that "foliated" does not merely mean having leaves or laminæ, and that schist does not merely mean being divided into leaves or laminæ, the modern British technical meaning of the word may be arrived at; but it is essential to remember that in France "schiste" and "feuilleté" are applied to "ardoise" (roofing-slate), and must be sharply distinguished from the modern British "schist" and "foliation." All three terms will be found in the letterpress of fig. 136 in Daubrée's Geol. experimentale, p. 395.

There seems to be no laxity in the use of "schiste" by French petrologists. The term defines a fissile rock. When used for a crystalline schist, the crystalline constituents are mentioned, *e.g.* "mica-schistes, talc-schistes," etc.; and "quartzites schisteux," whose "feuilleté," is caused by mica, chlorite, talc, or oligiste (Daubrée, *loc. cit.* p. 399).

The difficulty which arises from the definition of "schist" adopted by British petrologists is that of uncertainty. A "schist," say they, is a highly metamorphic rock where the mineral changes are great; not a rock in which the mineral changes are but slight. Clearly, then, there exists an intermediate debatable set of rocks, to which the term "schist" is not applicable. Who is to define the borders of this petrological "No man's land"—the area in which the rocks occur described by Mr. Teall as links between phyllites and mica-schists?

The true obstacle to the selection of a consistent nomenclature that will define the geologist's meaning, and not fly in the face of its own etymology, lies in the fact that two words of identical meaning, used indifferently by our early geologists, have assumed to themselves technical meanings which place them at the opposite extremes of the series of fissile rocks. Could English-speaking geologists revert to the old simple meaning of "schist," we might have some such series as "clay-schist," "sub-crystalline schist," and "crystalline schist"; in lieu of slate, phyllite, and schist. The name of the dominant mineral being prefixed would define the crystalline peculiarity; and if advisable, to distinguish detrital minerals from induced minerals, the words micaceous, talcose, hornblendic, etc., might be resorted to. "Slate," unfortunately, to the world means roofing-slate.

Under the present system it is often impossible to feel sure of a geologist's meaning; and it is equally impossible to describe a fissile rock with any certainty that the definition will be understood by others. A most remarkable instance of this difficulty is that of the Devonshire rocks, so long known as chlorite-schists. Mr. Teall has avoided giving them a specific name, and has simply called

them green rocks. But to distinguish two sets of Devonshire rocks as "greenstones" and "green rocks," as I myself did in my own paper on the subject, is to make a very fine technical distinction, and one very likely to confuse the non-technical reader. It need scarcely be mentioned that the green rocks, like the greenstones, are often grey; and that some of the chlorite-schists, *alias* green rocks, are, to all appearance, neither green, chloritic, nor schistose: but this is a mere detail.

Postscript.—The foregoing notes were out of my hands before I had had the advantage of seeing Mr. L. Fletcher's recent work, "An Introduction to the Study of Rocks," in which the author classes phyllites with argillaceous schists, and proposes the term "mero-crystalline" to describe volcanic rocks which are not holo-crystalline. If "mero-crystalline" might also be applied to schists which are not holo-crystalline, it would greatly facilitate the description of certain intermediate rocks which have been hitherto indescribable. In Geol. Mag. 1892, Vol. IX, Pls. VII and VIII, two rocks are figured, and elsewhere described as a quartz-schist and a chlorite-schist. Both these are courtesy titles, as neither rocks are preeminently fissile; moreover, the one is not holo-crystalline and the other is not prominently chloritic. What is much wanted is a substantive to correspond with the adjective "schistose," a term often used to define fissile volcanic rocks which have no pretensions to the title "schist"; *e.g.* a "schistose diabase." "Schistoid" would be convenient, but barbarous. A "mero-crystalline quartz-schistoid with detrital quartz and tourmaline" would sufficiently define the prominent characteristics of the one rock above mentioned, whereas "an holo-crystalline albite-uralite-schistoid" would indicate the salient peculiarities of the other. In the one rock the description would suggest to the reader a sedimentary origin, and in the other a volcanic one, a result much to be desired in the cases in question.

REVIEWS.

I.—Report on the Department of Mines of Western Australia for 1894. Perth, 1895.

THE rapid progress and brilliant prospects of the gold-mining industry in Western Australia will cause this White-book to be carefully read by great numbers of people in this country. As was to be expected, there is much information given concerning the auriferous districts and the mines in them, over two-thirds of the reading matter consisting of a report by Mr. S. Göczel, the Assistant Government Geologist, on the goldfields of the interior. Mr. Göczel's facts are interesting, but he buries them beneath such a mass of stilted and redundant phraseology that the process of digging them out is far from enjoyable, and will hardly be a relaxation to the gold-miner. He tells us that Archæan rocks underlie the whole of the great interior tableland, and that they are

covered here and there by thin cappings of unfossiliferous grits, sandstones, and conglomerates, which are said, on what appears to be somewhat slender grounds, to be of Cambrian age. Eruptive masses of diorite and schistose felspar-amphibolites have been forced through breaks in the Archæan rocks, and, at a somewhat later date, banded diabases were also intruded. The gold deposits generally occur in the stretches of country occupied by these old "greenstones," and were perhaps formed before the volcanoes became extinct. As Mr. Göczel puts it: "Doubtlessly [*sic*] the formation of lodes commenced with the first break in the lythosphere, but the formation of the bulk of primary gold deposits in this region is due to a hydrothermal gold emanation, most probably connected with and caused by volcanic subsidences during the late periods of the Palæozoic era." In future reports returns of the amount of machinery of all kinds on the goldfields will be made, so as to show the rate of progress. It would be useful if the output of the individual mines and districts were also tabulated.

The coalfields, on which the gold-mines will depend for their life, are dealt with by the Government Geologist, Mr. H. P. Woodward. He finds the coal in the Collie field, which seems to be of true Carboniferous age, to be a compact, splinty, bituminous coal of the non-caking class, containing 51 per cent. of fixed carbon, 32 per cent. of gas, 11·5 per cent. of water, and 4·3 per cent. of ash. The best sample of Collie coal was about equal for heating purposes to the average coals of New South Wales and Victoria. Mr. Woodward also examined the south-western portion of the colony with a view to the discovery of fresh coalfields, but he found no indications of any valuable deposits there. He gives, however, an interesting sketch of the geological history of the south coast, explaining the formation of the thin beds of sandy-brown coal, which have given rise to some hopes that workable coal would be found in that part of the colony.

II.—Palæontology of New York, Vol. VIII, Part II: an Introduction to the Study of the Genera of the Palæozoic Brachiopoda. By James Hall, assisted by John M. Clarke, Albany. New York, 1894, 4to, pp. 394, plates xxi–lxxxiv (Charles Van Benthuysen and Sons).

THIS, we regret to learn, forms the concluding volume of the "Palæontology of New York," a fine series forming part of "The Natural History of New York," inaugurated by Governor W. H. Seward during his administration 1839–42. In 1843 Prof. James Hall was placed in charge of the palæontology, and he has numbered many now well-known geologists and palæontologists among his assistants in the State Geological Survey during his half century of Directorship. In a preface dated Albany, December 1894, he gives an interesting account of the history and vicissitudes of this great work. Mr. J. M. Clarke joined in 1886, and aided in the preparation of volumes vii and viii, which latter was published in two parts as an "Introduction to the Study of the Genera of Palæozoic

Brachiopoda." The text of the second part, just issued complete, has already been noticed in this Magazine,[1] as it was circulated in two fasciculi among students on account of the long delay interposed in the printing of the plates, now most happily accomplished. They form a magnificent series, over sixty in number, with many hundreds of beautiful figures illustrating the Palæozoic Spiriferidæ, Rhynchonellidæ, and primitive Terebratulidæ, skilfully delineated by former assistants, Mr. R. P. Whitfield and Mr. E. Emmons, and finely lithographed by Mr. P. Ast. Each plate is accompanied by descriptions and legend, with a textual reference facilitating comparison. Nearly 468 preparations of internal structure were made by Prof. Clarke for this volume. Two figures are given on pl. lxxxiv—figs. 34 and 35—of the new genus *Torynifer*, of which but a single fragment is known. It bears, however, the critical structure which separates it from other genera. The type, *T. criticus*, is from the Lower Carboniferous St. Louis group of La Rue, Kentucky. This genus, "with general relations less athyroid than orthoid," was thus briefly described in the "Annual Report of the State Geologist of New York" for 1893, p. 943, vol. ii, Palæontology: "The shells athyroid in external aspect, but with a well-defined cardinal area and a distinct spondylium in the pedicle valve supported by a median septum." The systematic classification finally adopted has also been already epitomized.[2] We now quote in full a frank additional statement appended on page 385½ (vol. viii, pt. ii).

"The preceding table of Classification of the Brachiopoda is presented with many reservations and in deference to the general opinion expressed by brachiopodists at the present time; but the author believes that it is not the grouping which will be finally sustained. While much of it is an expression of the natural relations and succession of types, there are some portions which are not satisfactory. There seems a more natural succession in the line of the Pentameroids through the Amphigenidæ and the Rensselœridæ to the Centronellidæ than directly from the Rhynchonellidæ. There is also quite as much, or more, reason for believing the Rhynchonellids to be the progenitors of the spire-bearing forms than that they are the progenitors of the loop-bearing forms. The Rhynchonelloid type began early, is persistent and abundant through all the Palæozoic faunas, and, although the transition from these forms to the loop-bearers may be considered the more simple, there is yet much required to show the natural succession, which is more completely accomplished from the Pentameroids to the loop-bearing forms through *Amphigenia* and *Rensselœria*. That the brachia of Rhynchonellids may unite and form a loop seems a very natural inference, and in some forms is nearly accomplished. It would appear that in the Zygospiroids, which have externally a Rhynchonelloid aspect, the loop is completed by the formation of a jugum; but it goes still

[1] Geol. Mag., Dec. III, Vol. X, No. 353, p. 518, Nov. 1893.
Ibid., Dec. IV, Vol. I, No. 358, p. 172, April 1894.
Ibid., Dec. IV, Vol. II, No. 369, pp. 103–113, March 1895.

[2] Geol. Mag., Dec. IV, Vol. II, No. 369, pp. 103–113, March 1895.

farther, and from the junction of these crura are continued in one or two volutions. If such conditions occur in the older forms of the Zygospiridæ, there is no apparent reason why they may not occur elsewhere among the various spire-bearing genera which have a Rhynchonelloid aspect, and it seems a much more natural inference that the development should have been in the line of the Retziidæ or Rhynchospiridæ."

These remarks coincide with the genuine philosophic spirit which has throughout characterized a work which not only fitly illustrates the Natural History of New York State in long past ages, but forms a valuable addition to knowledge of the Brachiopoda in general, and one which cannot fail to exert an important influence on future researches throughout the world. It is given to few to witness the satisfactory completion of a great work conceived over half a century ago, and we offer the veteran State geologist and palæontologist of New York our heartiest congratulations on the successful termination of his lifelong labours.[1]

. . . . . .

The Brachiopoda of the early Cambrian faunas of the St. John group, New Brunswick, have also been studied with care by Mr. G. F. Mathew, who has described and figured several species in a valuable memoir entitled "The Protolenus Fauna," communicated to the Transactions of the New York Academy of Sciences in March of the past year.[2]

Mr. S. S. Buckman gave some instructive "Notes on certain Brachiopoda" from the Secondary deposits of England in his paper "On the Bajocian of the Mid-Cotteswolds," contributed to the Geological Society of London[3]—serial studies of considerable importance, chiefly relating to Rhynchonelloids.

Lastly, the number of genera and species of recent Brachiopoda has been augmented by Mr. W. H. Dall, who has described and figured several interesting forms dredged in deep water during the "Albatross" expedition, "chiefly near the Hawaiian Islands, with illustrations of hitherto unfigured species from North-west America," in the Proceedings of the United States National Museum.[4] This paper defines *Frieleia*—a new genus of the Rhynchonellidæ, with a spondylium and a smaller number of brachial coils than are present in *Hemithyris*, to which genus it bears most external resemblance. It also clears up misconceptions relating to previously described forms such as *Frenula Jeffreysii*, and gives valuable data on specific development.

AGNES CRANE.

[1] We learn from a cosmopolitan list compiled by Mr. J. M. Clarke that 460 publications, relating to the Geology and Palæontology of the State of New York, were issued by various authors during the years 1876 to 1893 inclusive.

[2] Vol. xiv, pp. 101–153, pls. i and ii.

[3] Quart. Journ., vol li, pp. 445–462, pl. xiv, August 1895.

[4] Vol. xvii, pp. 713–733, pls. xxiv, xxx–xxxii. Report xxxiv.

III.—Triadische Cephalopodenfaunen der Ostsibirischen Küstenprovinz. Von Dr. Karl Diener, in Wien. Mit 5 Tafeln. Mémoires du Comité Géologique. Vol. XIV, No. 3. St. Pétersbourg, 1895.

The Triassic Cephalopod Fauna of the Coast Province of East Siberia. By Dr. Karl Diener, of Vienna.

IN several localities on the Muravief peninsula, not far from the well-known Russian naval station of Vladivostock, some outcrops of Triassic rocks have lately been discovered by the Russian geologist D. L. Ivanow, which contain a series of Cephalopods, which are described and figured in this memoir by Dr. Diener. A particular interest attaches to some of these fossils, since they show definite relations to the Cephalopods in the Triassic rocks of the Himalaya, now also being critically worked out by the same palæontologist.

The Siberian forms indicate two distinct horizons. The newer of these, which apparently is of the age of the Muschelkalk, consists of a dark, rusty-weathering sandstone, containing *Monophyllites sichoticus*, sp.n., *Ptychites*, sp., and *Acrochordiceras*, sp. The occurrence of these together in the same beds is noteworthy, since both in Spitzbergen and in the Himalaya, *Monophyllites* more especially characterizes the lower division of the Muschelkalk and *Ptychites* the upper.

The large majority of the Cephalopoda are, however, from a distinctly Lower Triassic horizon; they are nearly all casts in a very hard, light-gray, calcareous sandstone. They comprise the following: *Nautilus* sp. aff. *N. quadrangulo*, Beyr., *Orthoceras* sp. aff. *O. Panjabiensi*, Waag., *Orthoceras* sp. aff. *O. campanili*, v. Mojs.; *Dinarites latiplicatus*, sp.n.. *Ceratites minutus*, Waag.; *Danubites Nicolai*, sp.n., *Danubites*, sp.; *Ussuria Schmarœ*, gen. et sp.n., *U. Ivanowi*, sp.n., *Pseudosageceras*, gen.n., sp.ind., *Proptychites acutisellatus*, sp.n., *P. hiemalis*, sp.n., *Proptychites*, sp., *P. otoceratoides*, sp.n., *Xenaspis orientalis*, sp.n., *Ophiceras* cf. *Sakuntala*, Dien., *Meekoceras boreale*, sp.n., *Meekoceras*, sp., *M.* (*Kingites*) *Varaha*, sp.n., *M.* (*Koninckites*) *septentrionale*, sp.n.

The Ammonites in the above list chiefly belong to the Liostraca division; the Trachyostraca forms constitute but a small minority. As regards numbers, the genus *Proptychites* is the best represented, and the author proposes to distinguish the beds by the name of this genus, which, it may be noted, is also very abundant in the lower divisions of the Trias in the Salt Range. Whilst these Vladivostock beds have no species in common with the Triassic Olenek-beds of North Siberia, they contain two, if not three, species of Ammonites and a species of *Nautilus*, either identical with or closely related to forms in the *Otoceras*-beds of the Himalaya, and the author concludes that they may be regarded as belonging to the same horizon of the Lower Trias as these. This is lower than the Olenek-beds, and, in fact, the *Otoceras*-beds represent the oldest Cephalopod fauna of the Trias. The recognition of this marine zone of the Lower Trias on the Pacific coast is an interesting and important addition to our knowledge of the distribution of this formation. G. J. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—November 20, 1895.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read:—

1. "Additional Notes on the Tarns of Lakeland." By J. E. Marr, Esq., M.A., F.R.S., Sec. G.S.

This paper is supplementary to one by the author published in the Q.J.G.S., vol. li (1895). He gives additional notes on Wateredbath Tarn; describes Hard Tarn on Helvellyn, a pond whose outlet has gradually been diverted from a course over screes to one over solid rock; Hayeswater, a lakelet referred to by Dr. H. R. Mill as in some respects intermediate between the mountain-tarns and the valley-lakes; and Angle Tarn, Patterdale, a good example of a plateau-tarn. The results of his fresh observations tend to confirm the views expressed in his former paper.

2. "Notes on the Glacial Geology of Arctic Europe and its Islands.—Part I. Kolguev Island. By Col. H. W. Feilden, F.G.S.; with a "Report on the Erratic Boulders from the Kolguev Beds," by Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

Kolguev Island, about the size of Norfolk, lies about 50 miles from Arctic Russia and about 130 miles south-west of the nearest part of Novaya Zemlya, with soundings not exceeding 30 fathoms between it and Russia, and probably not more than 75 fathoms between it and Novaya Zemlya. It is entirely composed of a vast accumulation of glacio-marine beds. The northern two-thirds of the island consists of an elevated ridged area with a maximum height of 250 feet. The author has been furnished with notes by Mr. Trevor-Battye concerning the geology of this region. It is inferred from his observations that this elevated region is composed of beds of sand with erratic boulders not less than 80 feet deep, resting on clays—the "Kolguev Clays." Mount Bolvana rises as a symmetrical cone above the tundra, detached from the northern plateau, pointing, in the opinion of the author, to the occurrence of marine erosion.

The southern portion of the island is tundra, a dead flat of grass, bog, and peat-levels reaching to the sea; good sections of the Kolguev Clays are exposed in the gullies traversing it near the sea on the western coast. In the vicinity of the Gobista river the Kolguev Beds consist of clays merging here and there into sands. They are charged with boulders often ice-scratched, indicating continuous deposition in a comparatively deep sea. The beds yielded many shells of Arctic mollusca, such as *Saxicava arctica*, *Mya*, etc., apparently dispersed from top to bottom. The ice-pack has forced many fragments of semi-fossil wood on to the shore, no doubt worked up from a bed immediately below sea-level. No deposit was met with in Kolguev Island precisely similar to what is called "Till" in Scotland, though there are many Boulder-clays in Britain which are in no measure superior in toughness to those of Kolguev—for instance, those of the Yorkshire coast and the Chalky Boulder-clays of Norfolk.

It is suggestive that all the glacial deposits met with by the author in Arctic and Polar lands (except the terminal moraines now forming above sea-level) should be glacio-marine beds.

Prof. Bonney in his report describes the rocks brought home by the author. They include granite-gneiss (very like Archæan rocks), grit, chert, limestone with *Favosites* (Silurian or Devonian), limestone with *Amphipora ramosa* (Devonian), limestone with *Lithostrotion irregulare* (Carboniferous), and a fragment of a Jurassic belemnite. The fossils have been examined by Mr. E. T. Newton, F.R.S.

II.—December 4, 1895.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read :—

1. "On the Alteration of certain Basic Eruptive Rocks from Brent Tor, Devon." By Frank Rutley, Esq., F.G.S.

Two microscopic sections of rocks occurring on the north side of Brent Tor were examined, and a cursory glance suggested at once the idea that they might originally have consisted to a greater or less extent of extremely vesicular basalt-glass. No unaltered vitreous matter, except perhaps mere traces, can now be detected in these specimens, the interest of which lies in the assemblage of alteration-products which they contain. A third section cut from a small chip collected at the southern side of the base of the Tor consists of a highly vesicular lava of a hyalopilitic character, which may be regarded as an amygdaloidal glassy basalt.

The author gives a detailed account of the microscopic characters of the three sections, and discusses the history of the rocks, comparing them with Tertiary basic glass, and with the Devonian rocks of Cant Hill, which he described previously. He brings forward evidence in favour of the view that the original alteration of both the Brent Tor and Cant Hill rocks was palagonitic; and that while in the Brent Tor rocks the subsequent alteration of the palagonite into felsitic matter, magnetite, secondary felspar, epidote, and probably kaolin, and some serpentine and chlorite, was complete, it was only partial in the case of the Cant Hill rocks. We may, therefore, assume that palagonite is not the ultimate phase of alteration in basic igneous rocks.

2. "The Mollusca of the Chalk Rock: Part I." By Henry Woods, Esq., M.A., F.G.S.

In the introductory part of the paper the author gives an account of the characters, distribution, and literature of the Chalk Rock. He points out that the Chalk Rock fauna may be recognized at the same level in Northern France, N.W. Germany, Saxony, Silesia, and Bohemia; and on account of the wide distribution and distinctive features of this fauna, he suggests that the Chalk Rock merits a palæontological rather than a lithological designation, and proposes for it the term "zone of *Heteroceras reussianum*."

The main part of the paper is devoted to the consideration of the Cephalopoda, Gasteropoda, and Scaphopoda; and is based largely on the collection from Cuckhamsley (Berks) made by the late

Mr. Montagu Smith; but for the loan of many specimens the author is indebted to Mr. R. M. Brydone, Mr. C. Griffith, Mr. W. Hill, Dr. J. Morison, and Mr. James Saunders. In addition to some genera, of which sufficiently good examples for exact determination have not yet been obtained, the following are represented: *Nautilus, Ptychoceras, Heteroceras, Baculites, Prionocyclus, Pachydiscus, Scaphites, Crioceras, Emarginula, Pleurotomaria, Trochus, Turbo, Crepidula, Natica, Cerithium, Aporrhais, Avellana,* and *Dentalium.* Some new species are described, and the synonymy and distribution of the others treated in detail, figures and descriptions being given of the forms not previously well known. The account of the Lamellibranchs and the general conclusions are reserved for Part II.

III.—December 18, 1895.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read:—

1. "The Tertiary Basalt-plateaux of North-western Europe." By Sir Archibald Geikie, D.Sc., LL.D., F.R.S.

The author in this paper gives the results obtained by him in the continued study of Tertiary Volcanic Geology in the seven years which have elapsed since the publication of his memoir on "The History of Volcanic Action during the Tertiary Period in the British Isles." His researches have embraced the western islands of Scotland, St. Kilda, and the Faroe Islands.

(1) In an account of the rocks of the basalt-plateaux attention is particularly directed in this paper to a type of banded basic lavas which play an important part in the structure of the volcanic districts both of the Inner Hebrides and of the Faroes. The banding sometimes consists in layers of more highly vesicular structure, sometimes in alternations of distinctly different lithological character, such as close-grained basalt and more coarsely crystalline dolerite. These banded rocks are more particularly developed in the lower portions of the volcanic series. At a distance they might be mistaken for tuffs or other stratified deposits. They occupy a conspicuous place in the great precipices of the west and north of the Faroe Islands.

Numerous examples are cited of the ending-off of basalt-sheets in different directions, indicative of many local vents from which the lavas issued. An account is also given of tuffs and other stratified intercalations which occupy a subordinate place in the structure of the plateaux.

(2) A number of examples is given of the volcanic vents which form a characteristic feature of the basalt-plateaux. A remarkable row of five such vents was met with by the author at the base of the great cliffs on the west side of Stromo, in the Faroe Islands. They are occupied with agglomerate, and their saucer-shaped craters have been filled in by successive streams of lava from neighbouring vents, the whole being buried under the great pile of basalt-sheets forming the island of Stromo.

An instance of similar structure is described from Portree Bay,

the agglomerate in this case being connected with a thick and widespread sheet of tuff intercalated among the basalts. Another example is cited from the east end of the island of Canna, where the ejected volcanic blocks are associated with records of contemporaneous river-action.

(3) The paper describes in some detail the evidence for the flow of a large river across the lava-fields during the time when volcanic activity was still vigorous. Thick sheets of well-rolled gravel are intercalated among the basalts of the islands of Canna and Sanday. These masses of detritus consist mainly of volcanic material, but they include also abundant pieces of Torridon Sandstone and rocks from the Western Highlands. The current of water which transported them certainly came from the east. That it flowed while the volcanic vents continued in eruption is shown by the bands of tuff and the large blocks of slag contained in the conglomerates, as well as by sheets of vesicular basalt interstratified in the same deposits. From the terrestrial vegetation whereof the macerated remains are enclosed in the tuffs and shales, and from the entire absence of marine organisms, it may be confidently inferred that the water was that of a river. The large size of many of the rounded blocks that were swept along proves that this river must have been of considerable volume and rapidity. The stream probably drained some part of the Inverness-shire Islands, and wandered over the volcanic plain, following the inequalities of the lava-fields, sweeping away the loose detritus of volcanic cones, and being continually liable to have its course altered by fresh volcanic eruptions. An interesting section is cited from the island of Sanday, where what appears to be a portion of the ravine of one of the tributaries of this river, trenched in the basalts, filled with coarse shingle and buried under later basalts, remains in a picturesque sea-stack.

(4) Many additional details are given to illustrate the structure and behaviour of the basic sills which are so abundantly developed, especially at the base of the plateaux. Some of these sheets are of colossal proportions, as in the Shiant Isles, where a single, columnar bed is 500 feet thick. Others descend to extremely minute proportions, such as the slender layers and threads which have been injected into the coal and shale between the lower basalts in the Portree district. A remarkable instance of a sill traversing the centre of another is cited from the south-east of Skye, the younger sheet having a strongly developed skin of black glass on its upper and under surfaces. One of the most striking instances of a sill rising obliquely across a thick mass of the plateau-basalts is described from Stromo in the Faroe Islands.

(5) The author adds some additional particulars, more especially from Skye and St. Kilda, to his published account of the dykes which have taken so important a place in the origin and structure of the plateaux.

(6) Further observations are narrated regarding the great bosses of gabbro in the Inner Hebrides. In particular, the peculiar banded structure, already described from a part of the Cuillin Hills, is shown

to have a wide distribution in Skye, and to occur also in Rum. The remarkable alteration of the plateau-basalts as they approach the gabbros of Loch Scavaig is referred to, and the microscopic structure of these metamorphosed rocks is described in notes supplied to the author by Mr. A. Harker. An account is also given of the gabbros of St. Kilda, which display a considerable variety of texture and composition and include basalts and dolerites.

(7) The author, having been able to visit St. Kilda, describes the junction of the granophyre of that remote island with the basalts and gabbros. He brought away a series of specimens and photographs which demonstrate that the acid rock has been injected into the basic masses, traversing them in veins and enclosing angular pieces of them. The granophyre is precisely like that of Skye and Mull, and is traversed by veins of finer material, as in these islands. Where it has penetrated the basic rocks it sometimes forms a kind of breccia-matrix in which the pieces of dark material are enclosed. It has taken up a certain quantity of the basalt or gabbro, as is shown by the abundant brown mica and hornblende which have been developed in the acid rock, especially round the enclosed basalt fragments. The results of a microscopic examination of thin slices of the rock at the junction are furnished by Mr. Harker.

From Skye examples are given of triple dykes and sills, wherein a central band consists of granophyre or spherulitic felsite, while the two marginal bands are of basalt, diabase, or other basic material. There does not appear to be any ascertainable connection between the acid and basic parts of such compound intrusions. In some cases the basic, in others the acid, portion is the older.

(8) An account is given of the little islet of Hysgeir, about 18 miles to the west of the island of Eigg, which has been identified by Dr. Heddle with the rock of the Scuir of Eigg, and which the author has visited in two successive years. The "pitchstone" is precisely like that of the Scuir down to the most minute structure, as is shown by an examination of the rock under the microscope by Mr. Harker. There can be little doubt that this rock was a superficial lava like that of Eigg, and there seems every probability that it is really a westward continuation of the Scuir. The Hysgeir pitchstone everywhere slips under the sea, so that its bottom cannot be seen.

(9) By way of illustrating the probable history of the basaltic plateaux of North-western Europe, the author gives a short summary of the results of recent investigations of the modern volcanic eruptions of Iceland, especially by Th. Thoroddsen and A. Helland. He shows in how many ways the phenomena of that island explain the facts which are met with in the study of our Tertiary plateaux, and how, in some respects, the enormous denudation of these plateaux throws light on parts of the mechanism of the Icelandic volcanoes which are still buried under the erupted material.

(10) Reference is made to the evidence of considerable terrestrial movement since the Tertiary volcanic period, as shown by the

tilting of large sections of the plateaux in different directions, and also by the existence of actual faults. Besides the normal faults, which are not infrequent among the Western isles, there occur among the Faroe Islands instances of reversed faults, which probably indicate disturbance of a more serious character.

(11) The concluding section of the paper deals with the effects of denudation on the plateaux. With possibly some minor intervals of partial depression, the present Tertiary volcanic tracts of the British and Faroe Isles have remained as land ever since the volcanic period. Their valleys were probably begun before the close of the eruptions, and these hollows have been continuously widened and deepened ever since. The result is a stupendous memorial of the potency of the agents of geological waste. While the Inner Hebrides abound in most impressive illustrations of this denudation, they are inferior in that respect to the Faroes. The long level lines of basalt-sheets furnish, as it were, datum-lines from which the extent of erosion can be estimated and even measured. There is certainly no other area in Europe where the study of the combined influence of atmospheric and marine denudation can be so admirably prosecuted, and where the imagination, kindled to enthusiasm by the contemplation of such scenery, can be so constantly and imperiously controlled by the accurate observation of ascertainable fact.

2. "The British Silurian Species of *Acidaspis*." By Philip Lake, Esq., M.A., F.G.S.

In this paper descriptions are given of those species of *Acidaspis* in the Silurian of Britain which have hitherto been incompletely described. The British forms are compared with those from the same system in Sweden and Bohemia. Five, out of nine, are represented by the same or very closely allied species in Sweden; two in Bohemia. All the Swedish forms except one are represented in Britain, and one in Bohemia as well as in Britain.

CORRESPONDENCE.

THE FORMATION OF CHALK BOULDERS.

Sir,—I venture to think that the difficulties of the diminishing group of geologists who still reject the land-ice origin of the chief part of our British drift-deposits will not be greatly lessened by the two very interesting papers in your last Number—that by Prof. G. A. J. Cole on "The Destruction of the Chalk," and by the Rev. E. Hill on "East Anglian Boulder-clay." There is this common objection to both papers, as indeed to most of the arguments put forward to support the marine origin of the drifts, that while it is quite possible to ascribe certain observed phenomena to the action of floating ice, it is quite impossible to explain thus the whole group of facts presented by any district which is carefully and thoroughly examined. The 'extreme glacialist,' on the other hand, claims that the presence of an extensive ice-sheet, with its necessary

accompaniment in this latitude of heavy streams and flood-waters, does afford a sufficient explanation of all the known facts.

The landslips of Chalk on the Antrim coast, described by Professor Cole, seem to me insufficient even to account for the masses of Chalk in the Drift at Cromer. It is quite certain that the explanation will not apply to the masses of Upper and Lower Lias shale which occupy similar positions amid the Basement Boulder-clay in Filey Bay and at Bridlington in Yorkshire, nor to the patch of Speeton clay which has surmounted the Chalk of Flamborough Head, nor to the isolated shreds of sea-bottom and fresh-water deposits contained in the Boulder-clay in numerous localities on the same coast.

The position and character of these masses render the landslip theory quite inapplicable to them; yet their position is so closely analogous to that of the Chalk boulders of Cromer that we are compelled to suppose a common method of transportation.

There is a slight inaccuracy of fact in the Rev. E. Hill's paper, which, though not of much importance as it stands, may as well be corrected at once lest it reappear unexpectedly as a corner-stone in the argument of another writer on the subject. After mentioning that chalk-drift is found in Leicestershire up to 800 feet, the author adds, "which is far higher than any Northern Chalk." But the Chalk Wolds in Yorkshire rise to slightly over 800 feet in Garrowby Hill (808 feet), and continue for several miles in that vicinity to reach elevations of between 750 and 800 feet.

Douglas, Isle of Man.
December 8th, 1895.

G. W. Lamplugh.

ZONES OF THE CARBONIFEROUS.

Sir,—British palæontologists, as well as stratigraphical geologists, will welcome the news of Messrs. E. J. Garwood and J. E. Marr (Geol. Mag., Dec. IV, Vol. II, pp. 550-552, December, 1895), that there is some hope of dividing the British Carboniferous Limestone into zones. But, when they direct the attention of local observers to note the accurate horizons and localities of fossils, why should they pass by the numerous Crinoidea of our own Mountain Limestone as unworthy of special attention? From a study of these animals in North America, many divisions and correlations have been made in the beds there called "sub-Carboniferous," and the biological results obtained have been most valuable. But in Britain, as I pointed out some years ago, a true palæontology of our numerous Carboniferous Crinoidea remains impossible so long as all specimens are labelled, like the vast majority of those in our rich national collection, "Carboniferous Limestone, Yorkshire?" I am certain that attention to the Crinoidea would render results quite as important as those to be derived from "the Corals, Trilobites, Brachiopods, and Cephalopods"; and if the committee referred to will only accept my services, I shall be pleased to have the chance of examining any specimens which have attached to them labels of scientific value.

F. A. Bather.

British Museum (Nat. Hist.), *3rd December*, 1985.

PYROXENE AND SERPENTINE IN ASSOCIATION WITH EOZOÖN CANADENSE.

SIR,—I fear that in my short notice of the rock containing Eozoön at Côte St. Pierre, which was printed in last year's Volume (p. 292), I must have failed in clearness of expression, since my friend Sir William Dawson, in his interesting defence of "the animal nature of Eozoön," says (p. 505) there "seems to be no good evidence that any portion of the pyroxene has been changed into serpentine." But of that, as I endeavoured to intimate on parts of pages 297 and 298, I have as good evidence as is possible. My slices show every stage from an unaltered pyroxene (allied to malacolite) to serpentine. In one slice, where the "canal-system" is well preserved, a few residual bits of pyroxene remain among the serpentine; in all the close resemblance of the silicates indicates an identity of the origin, which can be proved in the case of some. His suggestion that the pyroxene may have originated from local showers of volcanic dust seems to me not very probable. Grains or crystals of pyroxene are, no doubt, ejected in fair abundance from certain volcanoes, but in company with basaltic scoriæ. It is difficult to understand how the latter could be sifted from the former, and if this has not been done, what has become of the abundant aluminous silicate? True, there is a little white mica in the crystalline limestone, but not enough to represent the ash even of a Limburgite. Moreover, I believe the augite of a basalt is generally the aluminous variety. Perhaps, however, he would appeal to an eruptive peridotite. Here almost all the material would ultimately produce serpentine; but, then, volcanoes discharging only olivine augite slag are extremely rare; indeed, I should hardly like to say as yet, notwithstanding Kimberley, that their existence has been proved.

T. G. BONNEY.

SWEDISH GRAPTOLITES.

SIR,—The November Number of the GEOLOGICAL MAGAZINE contains the conclusion of an English translation of Dr. G. Holm's paper "On *Didymograptus*, *Tetragraptus*, and *Phyllograptus*," upon which I trust you will allow me to make the following remarks:—

Speaking of *Isograptus gibberulus*, Nich., sp. (or, as he prefers to term it, *Didymograptus gibberulus*), Dr. Holm quotes a previous paper of mine, in which I have treated of this matter. In that paper I stated in the very beginning, in direct terms, that the fossil in question has two stipes. Further on a sicular appendage is mentioned which, at a long distance from the sicula, is not inconsiderably widening.

Now we have to remark that Hall (in his "Graptolites of the Quebec Group") has figured some specimens of *Tetragraptus Bigsbyi*, Hall, so placed on the slab that two stipes are wholly visible, while you can only see the profile of a third. Such a stipe affords some very remote resemblance to the appendage described, and in order to avoid the suspicion that my observations had been based upon specimens preserved in a similar manner, I have appended in a footnote this remark: "Since this dilatation (of the

sicular appendage) never takes place except much outside the surrounding stipes, it is almost impossible to make the mistake of considering the appendage as part of a third branch." This statement was singularly misinterpreted by Dr. Holm in his paper "On *Didymograptus*, etc." But, as I thought I had expressed myself pretty clearly, and did not fear that any other Swedish reader might misunderstand the meaning, after having privately pointed out his error to Dr. Holm, I did not think it called for any public reply. I was therefore not a little astonished at finding that in the English version my statement was still further misrepresented. The English reader must be convinced that my assertions on two consecutive pages are contradictory. But my statement in the before-mentioned footnote is, as everyone can see, in full accordance with the views presented on the preceding pages, and totally contrary to the version given by Dr. Holm.

Hoping shortly to find time for working out a description of an interesting Graptolite-type, which I have met with, I will for the present refrain from making any further remarks about the genus *Isograptus*, which, I believe, should still be maintained.

Lund, 8*th December*, 1895. Joh. Chr. Moberg.

MISCELLANEOUS.

Further Notes on Eozoön Canadense by Sir Wm. Dawson, C.M.G.

Note to Second Article.—I should have mentioned in this article that Dr. F. D. Adams has shown, by comparison of a number of detailed analyses, that several of the gneisses of the Grenville Series have the chemical composition of Palæozoic slates, and thus that there can be no chemical objection to regarding them as altered sediments. This I consider a very important observation; and I may refer for details to his paper in the American Journal of Science, July 1895, vol. L, p. 58.

Note to Third Article.—The tubes penetrating some of the larger specimens of Eozoön may perhaps be compared with the central canal in the modern *Carpenteria*.—W.D.

Sections of Bunter and Keuper, etc.

During the construction of the Seacombe branch of the Wirral Railway the strata have been examined by Mr. T. W. Davies and Mr. T. Mellard Reade. Sections of Bunter, Keuper, and Glacial Drift are described by them. They note evidences of denudation of the Bunter prior to the accumulation of the Keuper. The Glacial Drift was found to comprise two beds of Boulder-clay separated in places by sand. In the Lower Clay abundant Foraminifera were discovered, while but few occurred in the Upper Clay. (*Proc. Liverpool Geol. Soc.*, vol. vii, part 3.)

Mr. R. Bullen Newton is continuing his useful work on the Eocene Mollusca, and has described a number of Gasteropods which have hitherto received only MS. names. (*Proc. Malacological Soc.*, vol. i, part 7.)